[19]中华人民共和国国家知识产权局

[51]Int. Cl[7]

A61B 3/10

G06T 1/00

[12]发明专利申请公开说明书

[21]申请号 00127067.2

[43]公开日 2002年4月10日 [11]公开号 CN 1343479A

[22]申请日 2000.9.15 [21]申请号 00127067.2

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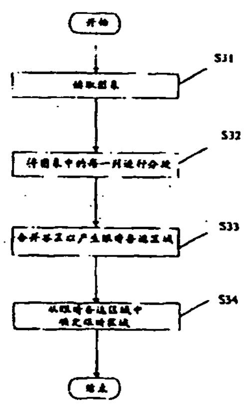
权利要求书8页 说明书20页 附图页数18页

[54]发明名称 图像处理方法和设备，图像处理系统以及存储介质

[57]摘要

本发明公开了一种人眼检测方法、设备和人眼检测系统，以检 测图象中的人眼。所述人眼检测设备包括读取装置，用于读取图象 每列的各象素的灰度值；分段装置，用于将每列分成多个区间，并 将各区间划分为谷区、中继区或峰区；合并装置，用于将每列的谷 区和其相邻列的谷区合并，并产生眼睛备选区域；确定装置，用于 从眼睛备选区域中确定人眼。按照本发明，可以实现一种可靠且快 速的人眼检测方法，以检测具有复杂背景的图象中的人眼。



ISSN 1008-4274

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TITLE OF THE INVENTION

Image Processing Method and Apparatus, system and Storage Medium

Field of the Invention

The present invention relates to an image processing method, apparatus, system, particularly relates to an eye detection method, apparatus, and system for detecting the human eye in an image, and a storage medium.

Background of the Invention

Image processing method for detecting or extracting a feature area of a given image is useful. For example, it can be used to recognize human eye of a given picture. Human eye is the most salient features in human face. It is very useful to detect the eye of human in an image, especially in a complex background. As to human being, it is easy for adult or the baby to tell human eye in an image with a complex background. However, no efficient way has been found out to detect the human eye in an image automatically and quickly.

Recently, much research and development has been conducted on automatic recognition technology, especially on eye detection. In general, the so-called "assumption and verification " method is used in eye detection. That is, first, an area in an image is assumed as the possible eye

area, and then the possible eye area is checked on the basis of some conditions to verify the real human eye area. For example, such a method is disclosed in Kin-Man Lam, "A Fast Approach for Detecting Human faces in a Complex Background ", Proceedings of the 1998 IEEE International Symposium on Circuits and System, 1998, ISCAS'98 Vol. 4, pp85-88, which is incorporated herein by reference. However, the detection efficiency is low as many eye area candidates are generated in an image.

THE SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide image processing method, apparatus and system, which can quickly or effectively detect or extract feature area of a given image.

The foregoing object of the present invention is achieved by providing an image processing method for detecting a feature portion in an image, comprising:

the read step of reading the gray level of each pixel in a given line of the image;

the segment step of segmenting the given into a plurality of intervals , and labeling each of the intervals as valley region , relay region or peak region;

the merger step of merging the valley region of the given line and the

valley region of its adjacent line, and generating the a candidate region; and

the determination step of determining the feature portion from said candidate region generated by the step of merging and generating.

Further, the foregoing object of the present invention is achieved by providing an image processing apparatus for detecting a feature portion in a an image, comprising:

read means for reading the gray level of each pixel in a given line of the image;

segment means for segmenting the given line into a plurality of intervals , and labeling each of the intervals as valley region , relay region or peak region;

merger means for merging the valley region of the given line and the valley region of its adjacent line, and generating a candidate region; and

determination means for determining the feature portion from said candidate region.

Further, the foregoing object of the present invention is achieved by providing an image processing system, comprising:

input device for inputting an image;

image processing device for detecting a feature portion in an image; and

output device for output the detected feature portion,

wherein the image processing device comprises read means for

reading the gray level of each pixel in a given line in the image; segment means for segmenting the given line into a plurality of intervals , labeling each of the intervals as valley region , relay region or peak region; merger means for merging the valley region of the given line and the valley region of its adjacent line, and generating a candidate region; and determination means for determining the feature portion from said candidate region.

Accordingly, it is another object of the present invention to provide an eye detection method, apparatus, and system which can quickly and easily detect human eye in an image, and a storage medium.

The foregoing object of the present invention is achieved by providing a human eye detection method for detecting the eye in an image, comprising:

the read step of reading the gray level of each pixel in the each column in the image;

the segment step of segmenting each column into a plurality of intervals , labeling each of the intervals as valley region , relay region or peak region;

the merger step of merging the valley region of the each column and the valley region of its adjacent column, and generating the eye candidate region; and

the determination step of determining the human eye from the eye candidate regions.

Further, the foregoing object of the present invention is achieved by providing a human eye detection apparatus for detecting the eye in an image, comprising:

read means for reading the gray level of each pixel in the each column in the image;

segment means for segmenting each column into a plurality of intervals , labeling each of the intervals as valley region , relay region or peak region;

merger means for merging the valley region of the each column and the valley region of its adjacent column, and generating the eye candidate region; and

determination means for determining the human eye from the eye candidate regions.

Further, the foregoing object of the present invention is achieved by providing a human eye detection system, comprising input device for inputting an image; human eye detection means for detecting human eye in an image; and output device for output the detected human eye.

Storage medium storing a program code of an eye detection, the program code including at least:

a code of reading the gray level of each pixel in the each column in the image;

a code of segmenting each column into a plurality of intervals , labeling each of the intervals as valley region , relay region or peak region;

a code of merging the valley region of the each column and the valley region of its adjacent column, and generating the eye candidate region; and a code of determining the human eye from the eye candidate regions.

A further object of the present invention is to provide an image processing method, apparatus, and system having novel function. The other objects and features of the present invention will become apparent from the following embodiments and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiment of the invention and , together with the description, serve to explain the principles of the invention.

Fig.1 is a block diagram showing the arrangement of an eye detection system according to an embodiment of the present invention;

Fig.2 is a block diagram showing the arrangement of the eye detection apparatus according to the embodiment of the present invention;

Fig.3A is the flow chart showing the procedure of searching human eye areas.

Fig. 3B is an example of an original image to be detected.

Fig. 4A is the flow chart for segmenting every column in an image.

Fig. 4B is an example for showing a column in an image.

Fig. 4C is an example for showing the gray level histogram of a column.

Fig. 4D is a diagram showing the gray level histogram of a column segmented into intervals.

Fig. 4E is an example for showing a segmented column in an image.

Fig.4F is a diagram showing the determination of a segment point in a column.

Fig.5A is the flow chart for merging valley regions in the columns.

Fig. 5B is a diagram showing the columns in an image and the valley regions and the seed regions in each column.

Fig. 5C is the image showing the detected eye candidate regions.

Fig.6A is the flow chart for determining eye areas.

Fig. 6B is a diagram showing an eye candidate region and its circum-rectangle.

Fig. 6C is the image showing the detected eye areas.

Fig.7A is the flow chart for adjusting segment border.

Fig.7B is a diagram showing the merger of the segment point to the adjacent intervals.

Fig. 7C is a diagram showing the merger of the relay region to the adjacent valley region.

Fig.8A is the flow chart for judging whether a valley region can be merged into a seed region.

Fig. 8B is a diagram showing a seed region's predicted valley region.

Fig. 8C is a diagram showing an overlap between two valley regions.

Description of the Preferred Embodiment

Preferred embodiment of the present invention will now be described in detail in accordance with the accompanying drawings.

System Arrangement

Fig.1 shows an example of an eye detection system according to an embodiment of the present invention. A printer 105 such as an ink-jet printer or the like, and a monitor 106 are connected to a host computer 100.

The host computer 100 has as software application software programs 101 such as a wordrocessor, spreadsheet, Internet browser, and the like, an OS (Operating System) 102, a printer driver 103 for processing various drawing commands (image drawing command, text drawing command, graphics drawing command) indicating output images, which are issued by the application software programs 101 to the OS 102, and generating print data, and a monitor driver 104 for processing various drawing commands issued by the application software programs 101 and displaying data in the monitor 106.

Reference numeral 112 denotes an instruction input device; and 113,

its device driver. For example, a mouse that points various kinds of information displayed on the monitor 106 to issue various instructions to the OS 102 is connected. Note that other pointing devices such as a trackball, pen, touch panel, and the like, or a keyboard may be connected in place of the mouse.

The host computer 100 comprises, as various kinds of hardware that can ran these software programs, a central processing unit (CPU) 108, hard disk (HD) 107, random-access memory (RAM) 109, read-only memory (ROM) 110, and the like.

As an example of the eye detection system shown in Fig.1, Windows98 available from Microsoft Corp., is installed as an OS in a popular PC-AT compatible personal computer available from IBM Corp., desired application programs that can implement printing are installed, and a monitor and printer are connected to the personal computer.

In the host computer 100, each application software program 101 generates output image data using text data which is classified into text such as characters or the like, graphics data which is classified into graphics such as figures or the like, image data which is classified into a natural image or the like, and so forth. Upon printing out the output image data, the application software program 101 sends a print-out request to the OS 102. At this time, the application software program 101 issues a drawing command group which includes a graphics drawing command corresponding to graphics data, and an image drawing

command corresponding to image data to the OS 102.

Upon receiving the output request from the application software program 101, the OS 102 issues a drawing command group to the printer driver 103 corresponding to an output printer. The printer driver 103 processes the print request and drawing commands input from the OS 102, generates print data that the printer 105 can print, and transfers the print data to the printer. The printer driver 103 performs an image correction process for the drawing commands from the OS 102, and then rasterizes the commands in turn on the RGB 24-bit page memory. Upon completion of rasterization of all the drawing command, the printer driver 103 converts the contents of the RGB 24-bit page memory into a data format that the printer 105 can print, i.e., CMYK data, and transfers the converted data to the printer 105.

Note that the host computer 100 can connect a digital camera 111 which senses an object image and generates RGB image data, and can load and store the sensed image data in the HD 107. Note that the image data sensed by the digital camera 111 is encoded by JPEG. The sensed image data can be transferred as image data to the printer 105 after it is decoded by the printer driver 103.

The host computer 100 further comprises an eye detection apparatus 114 for detecting the human eye in an image. The image data stored in HD 107 are read and processed by the eye detection apparatus 114. First, the possible positions of the human eye area are detected. Then, the

detected human eye in the image can be output to the printer 105 or monitor 106 under the control of OS 102.

Eye Detection Apparatus

Fig.2 is a block diagram showing the arrangement of the eye detection apparatus according to the embodiment of the present invention;

The eye detection apparatus 114 of the present embodiment comprises a read means 200, a segment means 201, a merger means 202 and a determination means 203. In the eye detection apparatus 114, a read means 200 executes an image read process. The gray levels of each pixel in the columns of an image stored in HD 107 are read by the read means 200. Referring to Figs. 4D and 4E, on the basis of the gray level of each pixel in a column C41, the column C41 of an image is segmented into a plurality of intervals I1-1, I1-2, ... I1-9, I1-10 by segment means 201. These intervals I1-1, I1-2, ... I1-9, I1-10 can be marked as three type, peak region, valley region and relay region, according to their average gray level of the image data. The terms "peak region, valley region and relay region" will be defined in detail later. Then, the valley regions of column C41 can be obtained. In the same way, the segment means 201 also divides other columns of the image into three types and obtains their valley regions respectively. After all the columns of an image have been marked as three types and their valley regions have been obtained, the

merger means 202 executes the merger process and mergers the valley regions in the adjacent columns. The merged valley regions are set as the human eye candidates. Then the human eye can be determined by determination means 203.

Detect the eye areas

An human eye detection process for an original image will be explained below with reference to the flow chart in Fig.3A. Fig. 3B is an example of an original image to be detected. Assume that the original image is stored in a predetermined area in the HD 107 or the RAM 109, or the like.

Referring to Fig.3A, read means 200 reads the gray level of each pixel in the columns of the original image to be detected in step S31. If the original image is encoded by, e.g., JPEG, the read means 200 must first decode it before reads its image data. Of course, all the gray levels for every columns of the original image can be read at one time, or they can be read sequentially or respectively. In the preferred embodiment, colume of the image is read, however, row of the image can be read in case the given image has been related to 90°. In step S32, every columns of the original image are segmented into many intervals by the segment means 201. With reference to Fig 4E, the lengths of every intervals I1-1, I1-2, ... I1-9 and I1-10 are variable. For example, the length of interval I1-1 does not equate to the length of interval I1-2. Some of the segmented

intervals are marked as the valley regions on the basis of their average gray levels of image data. In step S33, the valley regions in the adjacent columns are merged to generate the eye candidate regions by the merger means 202. Since the valley regions in each column have different length, the sizes of the eye candidate regions are also different from each other. In step S34, the human eye areas in the eye candidate regions are determined by the determination means 203. Thus, the human eye can be detected. Then, the image that has undergone human eye detection process is output to the monitor 105 or to the printer 104.

Segment Every Column of an Image

Fig.4A is the flow chart for segmenting every column in an image in step S32.

For the better understanding of segment process, the terms " valley region, peak region and relay region" are defined as follows.

Fig. 4B is an example for showing a column in the image. Referring to Fig.4B, a column C41 of the original image is read by the read means 200. Fig. 4C shows a gray level histogram of the column C41. Fig. 4D is a gray level histogram of the column segmented into intervals. In Fig. 4D, the reference numerals I1-5, I1-6, I1-9 represent the segmented intervals.

Fig. 4E is the segmented column of an image in Fig. 4B. Referring to Fig. 4E, the image data of a column C41 in an image is read by a read

means 200. The column C41 is segmented into 10 intervals I1-1, I1-2, … I1-9 and I1-10. The interval's size is the number of the pixels in an interval. For example, if the interval I1-2 comprises 12 pixels, the interval I1-2's size is 12. The interval's gray level is the average gray level of pixels in an interval.

With reference to Fig. 4D and 4E, if an interval's gray level is less than its adjacent intervals' gray level, then the interval is called valley region. If an interval's gray level is bigger than its adjacent intervals's gray level, the interval is called peak region. On the other hand, if an interval's gray level is between its adjacent interval's gray levels, such an interval is called relay region. As to column C41 of the embodiment, the gray levels of intervals from I1-1 to I1-10 are 196, 189, 190, 185, 201, 194, 213, 178, 188, 231 respectively. As to interval I1-6, its gray level is 194, and the gray levels of its adjacent intervals I1-5, I1-7 are 201 and 213. Since the gray level of interval I1-6 is less than that of its adjacent intervals I1-5 and I1-7, the interval I1-6 is determined as a valley region. In the same way, intervals I1-2, I1-4 and I1-8 are also determined as valley regions. As to interval I1-5, its gray level is 201, and the gray levels of its adjacent intervals are 185 and 194 respectively. Since the gray level of interval I1-5 is bigger than that of its adjacent intervals I1-6 and I1-7, the interval I1-5 is determined as a peak region. In the same way, intervals I1-1,I1-3,I1-7 and I1-10 are also determined as peak regions. Further, as to interval I1-9, its gray level is 188, the gray levels

of its adjacent I1-8 and I1-10 are 178 and 231. Since the gray level of interval I1-9 is between the gray levels of its adjacent intervals I1-8 and I1-10, interval I1-9 is determined as a relay region.

Because a valley region is also an interval, the way to compute the valley region's gray level and size is the same as that to compute the interval's gray level and size. It is also applied to compute the gray level and size of a peak region or a relay region.

The process for segmenting every column in an image in step S32 will be explained below with reference to Fig. 4A.

Referring to Fig. 4A, the gray levels of every pixels in the first column from the most left of the detected image are read out in step S41. In order to segment the column into intervals in the form of three types, i.e., valley region, peak region and relay region, the segment points have to be determined.

In step S42, whether a pixel of the column is a segment point can be determined according to the first and second derivative value of the pixel's gray level. Fig.4F is a diagram for showing the procedure to determine whether a pixel is a segment point in a column. With reference to Fig. 4F, two adjacent pixels Pi1 and Pi2 are given in a column. Then the first and the second derivative values of these two pixels Pi1, Pi2's gray level can be calculated by :

$$F(x)=f(x)\circledast g(x)=\int_{-\infty}^{+\infty} f(t).g(x-t)\,dt.$$

where x is the position of a pixel, f(x) is the gray level of pixels, g(x)

is a Gauss function, i.e. $g(x)=\exp(-x^2/2)/\sqrt{2}$. F(x) is the convolution of f(x) and g(x). Then, the first and the second derivative values of F(x) are determined as the first and the second derivative values of a pixel x. As an example, the first derivative values of the pixels Pil and Pi2's gray level are assumed as D1f and D2f, the second derivative values of the pixels Pil and Pi2's gray level are assumed as D1s and D2s. If the product of D1s and D2s is less than zero, or D2s is equal to zero, and the absolute value of D2f is bigger than a predetermine value, then the pixel Pi2 is determined as a segment point. Otherwise, the pixel Pi2 is determined as a non-segment point. As to the preferred embodiment, the gray levels of pixels Pi1 and Pi2 are 50 and 150. From the above equation, D1f, D2f, D1s and D2s can be determined as 64, 28, -14 and 86. We set the predetermined value as 4. Since D1s * D2s= -1204 < 0, the absolute value of D2f is 28 >4, then the pixel Pi2 is determined as a segment point.

Thus, the several segment points s11, s12, ... s19 can be obtained in step S42. After the segment points in a column have been determined, the column can be segmented into several intervals in step S43. Then, in step S43, the intervals are divided as valley region, peak region and relay region in accordance with the gray levels of the intervals. The border of intervals is adjusted in step S45. The detail of step of S45 will be described using detailed flow chart. In step 46, it is checked if all columns in the detected image have been segmented. If the column to be segmented is not the last column of the detected image, the flow goes to

step S47. In step S47, the gray levels of every pixels in the next column are read out. Then the flow returns to step S42 to repeat the process in step S42 and the subsequent steps. However, if the column to be segmented is the last column of the detected image in step 46, i.e. all columns have been segmented, the flow ends in step S48.

Alternatively, the above-mentioned segment process can be performed from the first column of most right of the detected image.

Merger Valley Regions to Generate Eye Candidate Regions

Fig.5A is the flow chart for merging valley region in the columns in step S33 in Fig. 3A. Fig.5B is a diagram showing the columns in an image and the valley regions and the seed regions in each column. In Fig.5B, an image has been divided into n columns Col1, Col2, ... Coln.

With reference to Fig. 5A and 5B, all the valley regions S1, S2, S3 and S4 in the first column Col1 (most left) of the detected image are set as seed regions in step S51. A seed region is an aggregation of one or some valley regions. Since the gray level of a valley region is less than that of a peak region or a relay region, a seed region is usually a dark area in a column.

In step S52 of Fig. 5A, the first valley region V2-1 in next column Col2 is read out. Then the flow advances to step S53. In step S53, the first seed region S1 is read out. In step S54, it is checked if the valley region V2-1 of column Col2 can be merged into the seed region S1 on the basis

of the valley region V2-1 and the seed region S1. If the valley region V2-1 of the valley region V2-1 can be merged into the seed region S1, then the flow goes to step S56 and merge the valley region V2-1into the seed region, then the valley region becomes a part of the seed region. However, if it is checked that the valley region V2-1 can not be merged into the seed region S1 in step S54, the flow goes to step S55. In the present embodiment, valley region V2-1 of column Col2 can not be merged into seed region S1. The flow advances to step S55, in step S55, it is checked whether the seed region is the last seed region. If the seed region is not the last seed region, then next seed region is read out in step S57 and the flow returns to step S54 to repeat the processes in step S54 and the subsequent steps. In the present embodiment, seed region S1 is not the last seed region, so in step S57 the next seed region S2 is read out, and so on. If it is checked in step S55 that the seed region is the last seed region, for example, seed region S4 as shown in Fig 5B, then the flow advances to step S58 and set the valley region that can not be merged into a seed region as a new seed region. Referring to Fig. 5B, since valley region V2-1 of column Col2 can not be merged into seed regions S1, S2, S3 or S4, that is a valley region that can not be merged into any existing seed region, then valley region V2-1 of column Col2 is set as a new seed region in step S58.

In step S59, it is checked if all the valley regions in the column Col2 have been processed. If processing for all the valley regions in the

column Col2 is complete, the flow goes to step S511. In step S511, it is checked if all the columns have been processed. If the column is not the last column of the detected image, then the flow returns to step S52 to repeat the processes in step S54 and the subsequent steps. As column Col2 is not the last column of the detected image, the flow returns to step S52. If all the columns have been processed, for example, if the column is the last column Coln, the flow advances to step S520. In step S520, all the seed regions are set as eye candidate regions. Then the flow ends in step S521. Fig. 5C is an example showing the result for merging valley regions to generate eye candidate regions in columns in a detected image in step S33.

Determine Eye Areas

Fig. 6A is the flow chart for determining eye areas in step S34.

With reference to Fig. 6A, the first eye candidate region is read out in step S61. Then, the flow advances to step S62. In step S62, the gray level of an eye candidate region is calculated. As described above, an eye candidate region comprises one or more valley regions. If an eye candidate region is comprised of n valley regions, i.e. valley region 1, valley region 2, … valley region n, then the eye candidate region's gray level calculated in step S62 is given by :

$$DarkGrayl = (Valley1Grayl + Valley2Grayl \ldots + ValleynGray\ l)/n; \quad (1)$$

, where

DarkGaryl is an eye candidate region's gray level;

Valley1Grayl is the gray level of valley region 1;

Valley2Grayl is the gray level of valley region 2...

ValleynGrayl is the gray level of valley region n; and

n is the number of valley regions included in an eye candidate region.

Therefore, if an eye candidate region comprises 3 valley regions with gray levels of 10, 20 and 30, then the gray level of the eye candidate region will be (10+20+30)/3=20.

Referring to step S62 of Fig.6A, the gray level of an eye candidate region is calculated. If the eye candidate region's gray level is not less than a first threshold, for example, 160, the flow goes to step S610. In the present embodiment, the first threshold is within the range of 100 to 200. In step S610, the eye candidate region is determined as a false eye area and is rejected. Then the flow goes to step S68. In step S68, it is checked if all the eye candidate regions in the detected image have been processed. If it is not the last eye candidate region, then the next eye candidate region will be read in step S69, then the flow returns to step S62 to repeat the processes in step S62. However, if it is checked in step S68 that the eye candidate region is the last eye candidate region, then the whole eye candidate regions in the detected image have been determined, the flow ends in step S611.

Returning to step S62, if the gray level of the eye candidate region is less than the first threshold, the flow advances to step S63.

The background gray level of the eye candidate region is calculated in step S63. The background gray levels of valley regions included in the eye candidate region determine the background gray levels of an eye candidate region. A valley region's background gray level is the average gray level of its adjacent intervals' gray level. The eye candidate region's background gray level calculated in step S63 is given by :

DarkBGrayl = (Valley1BGrayl +Valley2BGrayl…+ValleynBGray l)/n; (2)

, where

DarkBGaryl is an eye candidate region's background gray level;

Valley1BGrayl is the background gray level of valley region 1;

Valley2BGray1 is the background gray level of valley region 2…

ValleynBGrayl is the background gray level of valley region n; and

n is the number of valley regions included in an eye candidate region.

Referring to step S63, the background gray level of an eye candidate region is calculated. If the eye candidate region's background gray level is not bigger than a second threshold in step S63, for example, 30, the flow goes to step S610. In the present embodiment, the second threshold is within the range of 20 to 80. In step S610, the eye candidate region is determined as a false eye area and is rejected. Then the flow goes to step

S68.

Returning to step S63, if the background gray level of the eye candidate region is bigger than the second threshold, the flow advances to step S64.

The difference of background gray level of the eye candidate region and its gray level is calculated in step S64. If the difference is not bigger than a third threshold in step S64, for example, 20, the flow goes to step S610. In the present embodiment, the third threshold is within the range of 5 to 120. In step S610, the eye candidate region is determined as a false eye area and is rejected. Then the flow goes to step S68.

Returning to step S63, if the difference of background gray level of the eye candidate region and its gray level is bigger than the third threshold, the flow advances to step S65.

The ratio of the width to the height of an eye candidate region is calculated in step S65.

As to the height and the width of an eye candidate region, we have the following definitions. Valley region's size is the number of pixels included in a valley region. For example, if a valley region comprises 5 pixels, then the valley region's size is 5. The size of an eye candidate region is the sum of the sizes of the valley regions included in the eye candidate region. The width of an eye candidate region is the number of valley regions included in the eye candidate region. The height Hd of an

eye candidate region is given by:

$$Hd = Sd/Wd; \quad (3)$$

Where,

Hd is the height of an eye candidate region;

Sd is the size of an eye candidate region;

Wd is the width of an eye candidate region.

With reference to step S65 in Fig. 6A, the ratio of the width to the height of an eye candidate region is calculated. If the ratio of the width to the height of an eye candidate region is not bigger than a fourth threshold in step S65, for example, 3.33, the flow goes to step S610. In the present embodiment, the fourth threshold is within the range of 1 to 5. In step S610, the eye candidate region is determined as a false eye area and is rejected. Then the flow goes to step S68.

Returning to step S65, if the ratio of the width to the height of an eye candidate region is bigger than the fourth threshold, the flow advances to step S66.

The ratio of the size of an eye candidate region and that of its circum-rectangle is calculated in step S66. Fig. 6B is a diagram showing an eye candidate region and its circum-rectangle. With reference to Fig. 6B, an eye candidate region D1 and its circum-rectangle DC1 are given. As seen from Fig. 6B, the eye candidate region's circum-rectangle DC1 is

the smallest rectangle that encircles the eye candidate region D1. The size of an eye candidate region's circum-rectangle is the number of pixels included in the circum-rectangle. The size of an eye candidate region is the number of pixels included in the eye candidate region.

Referring to step S66, the ratio of the size of an eye candidate region to that of its circum-rectangle is calculated. If the ratio is not bigger than a fifth threshold in step S66, for example, 0.4, the flow goes to step S610. In the present embodiment, the fifth threshold is within the range of 0.2 to 1. In step S610, the eye candidate region is determined as a false eye area and is rejected. Then the flow goes to step S68.

Returning to step S66, if the ratio of the size of an eye candidate region to that of its circum-rectangle is bigger than the fifth threshold, the flow advances to step S67, then an eye candidate region is determined as a true eye area.

After step S67, the flow advances to step S68 and determines whether the eye candidate region is the last eye candidate region. If NO, then the next eye candidate region is read in step S69 and the flow returns to step S62. If YES in step S68, then all eye areas are determined. Fig. 6C is an example showing the result for detecting eye areas in an image in step S33.

Adjust Segment Border

Fig.7A is the flow chart of adjusting segment border in step S45 in Fig. 4A.

With reference to Fig. 7A, the gray level of a segment point is compared with its two adjacent interval's gray level, then the point is merged into the interval whose gray level is close to the point's gray level in step S71. For example, referring to Fig. 7B, the gray level of segment point S is 80, its adjacent intervals are intervals In1 and In2. The gray levels of intervals In1 and In2 are 70 and 100 respectively. Since the gray level of interval In1 is close to that of point S, then S will be merged into interval In1.

Further, the flow advances to step S72. In step S72, the first relay region is read out. Then the gray levels of the relay region and its adjacent valley region and peak region are calculated in step S73. After the gray levels of them have been calculated, the flow advances to step S74. In step S74, a comparison is made to decide whether GR is less than GP*Th6+GV*(1-Th6), wherein, GR denotes the gray level of the relay region, GV denotes the gray level of the relay region's adjacent valley region, GP denotes the gray level of the relay region's adjacent peak region. Th6 is the sixth threshold, for example, 0.2. The sixth threshold is within the range of 0 to 0.5. If the decision of step S74 is NO, the flow goes to step S76. Otherwise, if the decision of step S74 is YES, then the relay region is merged into the valley region in step S75.

Fig. 7C is a diagram showing an example for merging of the relay

region to the adjacent valley region. X axis shown in Fig. 7C represents position of each column, Y axis shown in Fig. 7C represents gray level of each region.

Referring to Fig. 7C, relay region Re1's gray level is 25, valley region Va1's gray level is 20, and peak region Pe1's gray level is 70. The sixth threshold is set as 0.2, then

$GP*Th6+GV*(1-Th6o) = 70*0.2+20*0.8=30 > GR=25;$

Therefore, the decision in step S74 is YES, so relay region Re1 will be merged into the valley region Va1. Further, relay region Re 2'gray level is 40,peak region Pe2's gray level is 60, then

$GP*Th6+GV*(1-Th6) = 60*0.2+20*0.8=28 < GR = 40;$

Therefore, the decision in step S74 is NO, so relay region Re2 will not be merged into the valley region Va1.

Referring to step S76 in Fig. 7A, it is checked if all the relay regions in the detected image have been processed. If the relay region is not the last relay region, the next relay region will be read in step S77, then flow returns to step S73 to repeat the processes in step S73 and the subsequent steps. However, if it is checked in step S76 that the relay region is the last relay region, i.e. the processing for all relay regions is complete, the flow ends in step S78. Thus, the whole segment border in the detected image have been adjusted.

Judge Whether a Valley Region Can be Merged Into a Seed Region

Fig. 8A is the flow chart for judging whether a valley region can be merged into a seed region in step S54 in Fig. 5A.

Fig. 8B is a diagram showing a seed region's predicted valley region. A seed region's predicted valley region isn't a real existing valley region in any columns of the detected image. It is a valley region that is assumed in the next column of the column, in which the most right adjacent valley region of the seed region is, and its position is same as that of the most right adjacent valley region of the seed region. With reference to Fig. 8B, valley region Va3 is the most right valley region of seed region Se1. Valley region Va3 is in the column Col1, column Col2 is the next column of column Col1. Then valley region Va1 is the predicted valley region of seed region Se1. This predicted valley region is in column Col2, and its position is the same as that of valley region Va3 but in a different column.

Fig. 8C is a diagram showing an overlap region of two valley regions. The overlap region of two valley regions is an area in which the pixels belong to the two valley regions.

Referring to Fig. 8C, the interval from point B to point D is a valley region Va1, the interval from point A to point C is a valley region Va2, the valley region Va1 is the predicted valley region of the seed region Se1, the valley region Va2 is a real valley region in column Col2. Then, the interval from point B to point C is the overlap region of the valley region Va1 and the valley region Va2.

The procedure for judging whether a valley region can be merged into a seed region will be explained below with reference to the flow chart in Fig. 8A. Referring to Fig. 8A, the overlap region of a valley region and a seed region's predicted valley region is calculated in step S81.

After overlap region has been calculated, the flow advances to step S82. In step S82, a comparison is made to decide whether Osize/Max(Vsize, SVsize) is bigger than Th7, wherein, Osize is the size of overlap of the valley region and the seed region's predicted valley region, Max (Vsize, SVsize) is the maximum of the size of the valley region and that of the seed region's predicted valley region, Th7 is the seventh threshold, for example, 0.37. The seventh threshold is within the range of 0.2 to 0.75. If the decision of step S82 is NO, the flow goes to step S88. Then the valley region can not be merged into the seed region, the flow ends in step S89. Otherwise, if the decision of step S82 is YES, then the flow advances to step S83.

In step S83, the gray levels of the valley region and the seed region are calculated. Then the flow advances to step S84. In step S84, a comparison is made to decide whether |GValley-GSeed| is less than Th8, wherein GValley is the gray level of the valley region, GSeed is the gray level of the seed region. Th8 is an eighth threshold, for example, 40. The eighth threshold is within the range of 0 to 60. If the decision of step S84 is NO, the flow goes to step S88. Then the valley region can not be

merged into the seed region, the flow ends in step S89. Otherwise, if the decision of step S84 is YES, then the flow advances to step S85.

In step S85, the luminance values of the valley region's background, the seed region's background, the valley region and the seed region are calculated.

As to the luminance value of a pixel in an image, it can be calculated by:

$$G=1.2219*10^{-1}*L + 9.063*10^{-4}*L^2 + 3.6833526*10^{-5}*L^3 + 1.267023*10^{-7}*L^4+1.987583*10^{-10}*L^5 \quad (4)$$

Equation (4) is the non-linear relation between the gray level and the luminance value in the A.H.Munsel color system, where G is gray level of a pixel ranged from 0 to 255; and L is luminance level of a pixel ranged from 0 to 255.

Therefore, the luminance value of a pixel can be obtained from its gray level in an image. On the other hand, the gray level of a pixel can be obtained from its luminance value.

As to the present embodiment, the gray levels of pixels Pi1 and Pi2 in Fig. 4F are 50 and 150. With equation (4), the luminance values of pixels Pi1 and Pi2 can be determined as 128 and 206.

Referring to Fig. 8A, after step S85, the flow advances to step S86. In step S86, a comparison is made to decide whether Min((Lvb-Lv), (Lsb-Ls))/Max((Lvb-Lv), (Lsb-Ls)) is bigger than Th9, wherein Lv is the luminance value of the valley region, Ls is the luminance value of the

seed region, Lvb is the luminance value of the valley region's background, Lsb is the luminance value of the seed region's background. Min ((Lvb-Lv), (Lsb-Ls)) is the minimum of (Lvb-Lv) and (Lsb-Ls), Max ((Lvb-Lv), (Lsb-Ls)) is the maximum of (Lvb-Lv) and (Lsb-Ls), Th9 is a ninth threshold, for example, 0.58. The ninth threshold is within the range of 0.3 to 1. If the decision of step S86 is NO, the flow goes to step S88. Then the valley region can not be merged into the seed region, the flow ends in step S89. Otherwise, if the decision of step S86 is YES, the flow advances to step S87.

In step S87, the valley region is merged into the seed region, then the flow ends in step S89.

Note that the present invention may be applied to either a system constituted by a plurality of devices (e.g., a host computer, an interface device, a reader, a printer, and the like), or an apparatus consisting of a single equipment (e.g., a copying machine, a facsimile apparatus, or the like).

The objects of the present invention are also achieved by supplying a storage medium. The storage medium records a program code of a software program that can implement the functions of the above embodiment to the system or apparatus, and reading out and executing the program code stored in the storage medium by a computer (or a CPU or MPU) of the system or apparatus.

In this case, the program code itself read out from the storage medium

implements the functions of the above-mentioned embodiment, and the storage medium which stores the program code constitutes the present invention.

As the storage medium for supplying the program code, for example, a floppy disk, hark disk, optical disk, magneto-optical disk, CD-ROM, CD-R, magnetic tape, nonvolatile memory card, ROM, and the like may be used.

The functions of the above-mentioned embodiment may be implemented not only by executing the readout program code by the computer but also by some or all of actual processing operations executed by an OS (operating system) running on the computer on the basis of an instruction of the program code.

As can be seen from the above, the method of the present invention provides a fast approach for detecting human eyes in a picture with a complex background, without requiring the detected picture to have a very high quality, thereby substantially eliminating the possibility of the human eyes in the picture being skipped over. The method allows for the precision detection of human eyes under different scales, orientation and lighting condition. Therefore, in accordance with the present invention, with the method, apparatus or system, the human eyes in a picture can be quickly and effectively detected.

The present invention includes a case where, after the program codes read from the storage medium are written in a function expansion card

which is inserted into the computer or in a memory provided in a function expansion unit which is connected to the computer, CPU or the like contained in the function expansion card or unit performs a part or entire process in accordance with designations of the program codes and realizes functions of the above embodiment.

In a case where the present invention is applied to the aforesaid storage medium, the storage medium stores programs codes corresponding to the flowcharts (Fig.3A, 4A, 5A, 6A, 7A and 8A) described in the embodiments.

The embodiment explained above is specialize to detect human eye, however, the present invention is not limited to detect human eye, it is applicable to other detection method, for example, method to detect flaw portion on a circuit board.

As many apparently widely different embodiments of the present invention can be made without departing from the spirit and scope thereof, it is to be understood that the invention is not limited to the specific embodiments thereof except as defined in the appended claims.

WHAT IS CLAIMED IS:

1. An human eye detection method for detecting human eye in an image, comprising:

the read step of reading the gray level of each pixel in the each column in the image;

the segment step of segmenting each column into a plurality of intervals , and labeling each of the intervals as valley region , relay region or peak region;

the merger step of merging the valley region of the each column and the valley region of its adjacent column, and generating an eye candidate region; and

the determination step of determining the human eye from the eye candidate regions.

2. The method according to claim 1, wherein the segment step includes the step of labeling each interval as one of valley region, relay region and peak region based on the gray level of each the interval in a column.

3. The method according to claim 1, wherein the segment step includes the step of labeling each interval as one of valley region, relay region and peak region based on the luminance value of each interval in a column.

4. The method according to claim 1, wherein the segment step includes the step of labeling each interval in a column as one of valley region, relay region and peak region based on the respective gray level ratios of the interval to its two adjacent intervals.

5. The method according to claim 1, wherein the segment step includes the step of labeling each interval in a column as one of valley region, relay region and peak region based on the respective luminance value ratios of the interval to its two adjacent interval.

6. The method according to any one of claims 1 to 5, wherein further comprising the step of comparing the gray level of a segment point with that of its two adjacent intervals, and adding the segment point into the adjacent interval which has a gray level close to that of the segment point.

7. The method according to any one of claims 1 to 6, wherein further comprising the step of comparing the gray level of a relay region with that of its adjacent valley region and peak valley, and adding the relay region into the valley region on the basis of the gray levels of the adjacent valley region, peak region and the relay region.

8. The method according to claim 1, wherein the merger step comprising the steps of

setting each valley region in the first column of the image as a seed region respectively;

reading out the valley region of next column of the image,

determining whether the valley region can be merged into the seed

region,

merging the valley region that can be merged into the seed region;

setting the non-merged valley region as a seed region; and

determining the seed region which has no further merged valley region as an eye candidate region.

9. The method according to claim 8, wherein further comprising the step of comparing the size of overlap of the valley region and the seed region's predicted valley region, the valley region and the seed region's predicted valley region.

10. The method according to claim 8, wherein further comprising the step of comparing the gray level of the valley region and that of the seed region.

11. The method according to claim 8, wherein further comprising the step of comparing the gray levels of the valley region, the seed region, the background gray levels of the valley region and the seed region.

12. The method according to claims 1, wherein the determination step comprising the step of determining whether the gray level of the eye candidate region is less than the first threshold, where the first threshold is within the range of 100 to 200, preferably of 160.

13. The method according to claims 12, wherein the determination step further comprising the step of determining whether the background gray level of the eye candidate region is bigger than the second threshold, where the second threshold is within the range of 20 to 80, preferably of

30.

14. The method according to claims 13, wherein the determination step further comprising the step of determining whether the difference of background gray level of the eye candidate region and its gray level is bigger than a third threshold, where the third threshold is within the range of 5 to 120 , preferably of 20.

15. The method according to claims 14, wherein the determination step further comprising the step of determining whether the ratio of the width to the height of an eye candidate region is bigger than a fourth threshold, where the fourth threshold is within the range of 1 to 5, preferably of 3.33.

16. The method according to claims 15, wherein the determination step further comprising the step of determining whether the ratio of the size of an eye candidate region to that of its circum-rectangle is bigger than the fifth threshold, where the fifth threshold is within the range of 0.2 to 1 preferably of 0.4.

17. An human eye detection apparatus for detecting human eye in an image, comprising:

read means for reading the gray level of each pixel in the each column in the image;

segment means for segmenting each column into a plurality of intervals , labeling each of the intervals as valley region , relay region or peak region;

merger means for merging the valley region of the each column and the valley region of its adjacent column, and generating an eye candidate region; and

determination means for determining the human eye from the eye candidate regions.

18. The apparatus according to claim 17, wherein the segment means labels each interval as one of valley region, relay region and peak region based on the gray level of each the interval in a column.

19. The apparatus according to claim 17, wherein the segment means labels each interval as one of valley region, relay region and peak region based on the luminance value of each interval in a column.

20. The apparatus according to claim 17, wherein the segment means labels each interval in a column as one of valley region, relay region and peak region based on the respective gray level ratios of the interval to its two adjacent intervals.

21. The apparatus according to claim 17, wherein the segment means labels each interval in a column as one of valley region, relay region and peak region based on the respective luminance value ratios of the interval to its two adjacent interval.

22. The apparatus according to claims 17 or 21, wherein the segment means compares the gray level of a segment point with that of its two adjacent intervals, and adding the segment point into the adjacent interval which has a gray level close to that of the segment point.

23. The apparatus according to claims 17 or 22, wherein the segment means compares the gray level of a relay region with that of its adjacent valley region and peak valley, and adding the relay region into the valley region on the basis of the gray levels of the adjacent valley region, peak region and the relay region.

24. The apparatus according to claim 18, wherein the merger means sets each valley region in the first column of the image as a seed region respectively; reads out the valley region of next column of the image, determines whether the valley region can be merged into the seed region, merges the valley region that can be merged into the seed region; sets the non-merged valley region as a seed region; and determines the seed region which has no further merged valley region as an eye candidate region.

25. The apparatus according to claim 24, wherein the merger means compares the size of overlap of the valley region and the seed region's predicted valley region, the valley region and the seed region's predicted valley region.

26. The apparatus according to claim 24, wherein merger means compares the gray level of the valley region and that of the seed region.

27. The apparatus according to claim 24, wherein merger means compares the gray levels of the valley region, the seed region, the background gray levels of the valley region and the seed region.

28. An human eye detection system, comprising:

input device for inputting an image;

human eye detection device for detecting human eye in an image; and output device for output the detected human eye,

wherein the human eye detection device comprises read means for reading the gray level of each pixel in the each column in the image; segment means for segmenting each column into a plurality of intervals , and labeling each of the intervals as valley region , relay region or peak region; merger means for merging the valley region of the each column and the valley region of its adjacent column, and generating an eye candidate region; and determination means for determining the human eye from the eye candidate region.

29. An human eye detection system according to claim 28, wherein the input device is a digital camera for generating an image signal by sensing an object image.

30. An human eye detection system according to claim 28, wherein the input device is a scanner for generating an image signal by optically scanning a photo.

31. An human eye detection system according to claim 28, wherein the output device is a monitor for displaying the detected human eye.

32. An human eye detection system according to claim 28, wherein the output device is a printer for printing out the detected human eye.

33. Storage medium storing a program code of an eye detection, the program code including at least:

a code of reading the gray level of each pixel in the each column in

the image;

a code of segmenting each column into a plurality of intervals , labeling each of the intervals as valley region , relay region or peak region;

a code of merging the valley region of the each column and the valley region of its adjacent column, and generating the eye candidate region; and

a code of determining the human eye from the eye candidate region.

34. Storage medium storing a program implementing the method according to any one of claims 1 to 16.

35. Recording medium on which the human eye detected by the human eye detection method according to any one of claims 1 to 16 is formed.

36. An image processing method for detecting a feature portion in an image, comprising:

the read step of reading the gray level of each pixel in a given line of the image;

the segment step of segmenting the given into a plurality of intervals , and labeling each of the intervals as valley region , relay region or peak region;

the merger step of merging the valley region of the given line and the valley region of its adjacent line, and generating the a candidate region; and

the determination step of determining the feature portion from said candidate region generated by the step of merging and generating.

37. The method according to claim 36, wherein the segment step includes the step of labeling each interval as one of valley region, relay region and peak region based on the gray level of each the interval in the given line.

38. The method according to claim 36, wherein the segment step includes the step of labeling each interval as one of valley region, relay region and peak region based on the luminance value of each interval in the given line.

39. The method according to claim 36, wherein the segment step includes the step of labeling each interval in the given line as one of valley region, relay region and peak region based on the respective gray level ratios of the interval to its two adjacent intervals.

40. The method according to claim 36, wherein the segment step includes the step of labeling each interval in the given line as one of valley region, relay region and peak region based on the respective luminance value ratios of the interval to its two adjacent interval.

41. The method according to any one of claims 36 to 40, wherein further comprising the step of comparing the gray level of a segment point with that of its two adjacent intervals, and adding the segment point into the adjacent interval which has a gray level close to that of the segment point.

42. The method according to any one of claims 36 to 41, wherein further comprising the step of comparing the gray level of a relay region

with that of its adjacent valley region and peak valley, and adding the relay region into the valley region on the basis of the gray levels of the adjacent valley region, peak region and the relay region.

43. The method according to claim 36, wherein the merger step comprising the steps of

setting each valley region in the first line of the image as a seed region respectively;

reading out the valley region of next line of the image,

determining whether the valley region can be merged into the seed region,

merging the valley region that can be merged into the seed region;

setting the non-merged valley region as a seed region; and

determining the seed region which has no further merged valley region as a candidate region.

44. The method according to claim 43, wherein further comprising the step of comparing the size of overlap of the valley region and the seed region's predicted valley region, the valley region and the seed region's predicted valley region.

45. The method according to claim 43, wherein further comprising the step of comparing the gray level of the valley region and that of the seed region.

46. The method according to claim 43, wherein further comprising the step of comparing the gray levels of the valley region, the seed region,

the background gray levels of the valley region and the seed region.

47. An image processing apparatus for detecting a feature portion in a an image, comprising:

read means for reading the gray level of each pixel in a given line of the image;

segment means for segmenting the given line into a plurality of intervals , and labeling each of the intervals as valley region , relay region or peak region;

merger means for merging the valley region of the given line and the valley region of its adjacent line, and generating a candidate region; and

determination means for determining the feature portion from said candidate region.

48. The apparatus according to claim 47, wherein the segment means labels each interval as one of valley region, relay region and peak region based on the gray level of each the interval in the given line.

49. The apparatus according to claim 47, wherein the segment means labels each interval as one of valley region, relay region and peak region based on the luminance value of each interval in the given line.

50. The apparatus according to claim 47, wherein the segment means labels each interval in the given line as one of valley region, relay region and peak region based on the respective gray level ratios of the interval to its two adjacent intervals.

51. The apparatus according to claim 47, wherein the segment

means labels each interval in the given line as one of valley region, relay region and peak region based on the respective luminance value ratios of the interval to its two adjacent interval.

52. The apparatus according to claims 47 or 51, wherein the segment means compares the gray level of a segment point with that of its two adjacent intervals, and adding the segment point into the adjacent interval which has a gray level close to that of the segment point.

53. The apparatus according to claims 47 or 52, wherein the segment means compares the gray level of a relay region with that of its adjacent valley region and peak valley, and adding the relay region into the valley region on the basis of the gray levels of the adjacent valley region, peak region and the relay region.

54. The apparatus according to claim 48, wherein the merger means sets each valley region in the first line of the image as a seed region respectively; reads out the valley region of next line of the image, determines whether the valley region can be merged into the seed region, merges the valley region that can be merged into the seed region; sets the non-merged valley region as a seed region; and determines the seed region which has no further merged valley region as a candidate region.

55. The apparatus according to claim 54, wherein the merger means compares the size of overlap of the valley region and the seed region's predicted valley region, the valley region and the seed region's predicted valley region.

56. The apparatus according to claim 54, wherein merger means compares the gray level of the valley region and that of the seed region.

57. The apparatus according to claim 54, wherein merger means compares the gray levels of the valley region, the seed region, the background gray levels of the valley region and the seed region.

58. An image processing system, comprising:

input device for inputting an image;

image processing device for detecting a feature portion in an image; and

output device for output the detected feature portion,

wherein the image processing device comprises read means for reading the gray level of each pixel in a given line in the image; segment means for segmenting the given line into a plurality of intervals , labeling each of the intervals as valley region , relay region or peak region; merger means for merging the valley region of the given line and the valley region of its adjacent line, and generating a candidate region; and determination means for determining the feature portion from said candidate region.

59. An image processing system according to claim 58, wherein the input device is a digital camera for generating an image signal by sensing an object image.

60. An image processing system according to claim 58, wherein the input device is a scanner for generating an image signal by optically

scanning a photo.

61. An image processing system according to claim 58, wherein the output device is a monitor for displaying the feature portions.

62. An image processing system according to claim 58, wherein the output device is a printer for printing out the feature portions.

63. Storage medium storing a program code of an image processing, the program code including at least:

a code of reading the gray level of each pixel in a given line in the image;

a code of segmenting the given line into a plurality of intervals , labeling each of the intervals as valley region , relay region or peak region;

a code of merging the valley region of the given line and the valley region of its adjacent line, and generating a candidate region; and

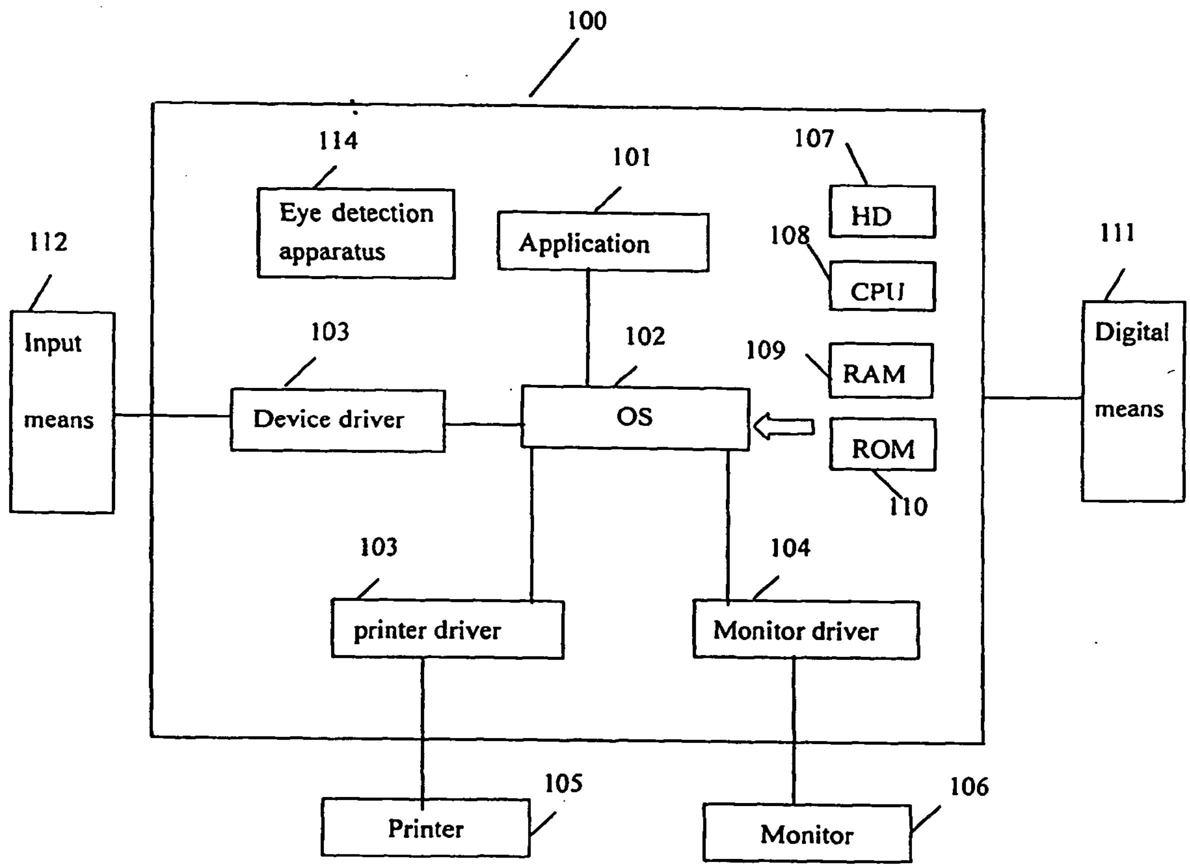
a code of determining the feature portion from said candidate region.

64. Storage medium storing a program implementing the method according to any one of claims 36 to 46.

65. Recording medium on which the feature portion detected by the image processing method according to any one of claims 36 to 46 is formed.

Abstract of the Invention

An eye detection method, apparatus, and system for detecting the human eye in an image are disclosed in the present invention. The eye detection apparatus comprises read means for reading the gray level of each pixel in the each column in the image; segment means for segmenting each column into a plurality of intervals , labeling each of the intervals as valley region , relay region or peak region; merger means for merging the valley region of the each column and the valley region of its adjacent column, and generating the eye candidate region; and determination means for determining the human eye from the eye candidate regions. According to the present, a reliable and fast method for detecting human eye in a complex background in an image is implemented. Since the eye area candidates can be easily filtered, the eye detection efficiency is high.



100
114
Eye detection apparatus
101
Application
107
HD
108
CPU
109
RAM
ROM
110
112
Input means
103
Device driver
102
OS
111
Digital means
103
printer driver
104
Monitor driver
105
Printer
106
Monitor

Figure 1

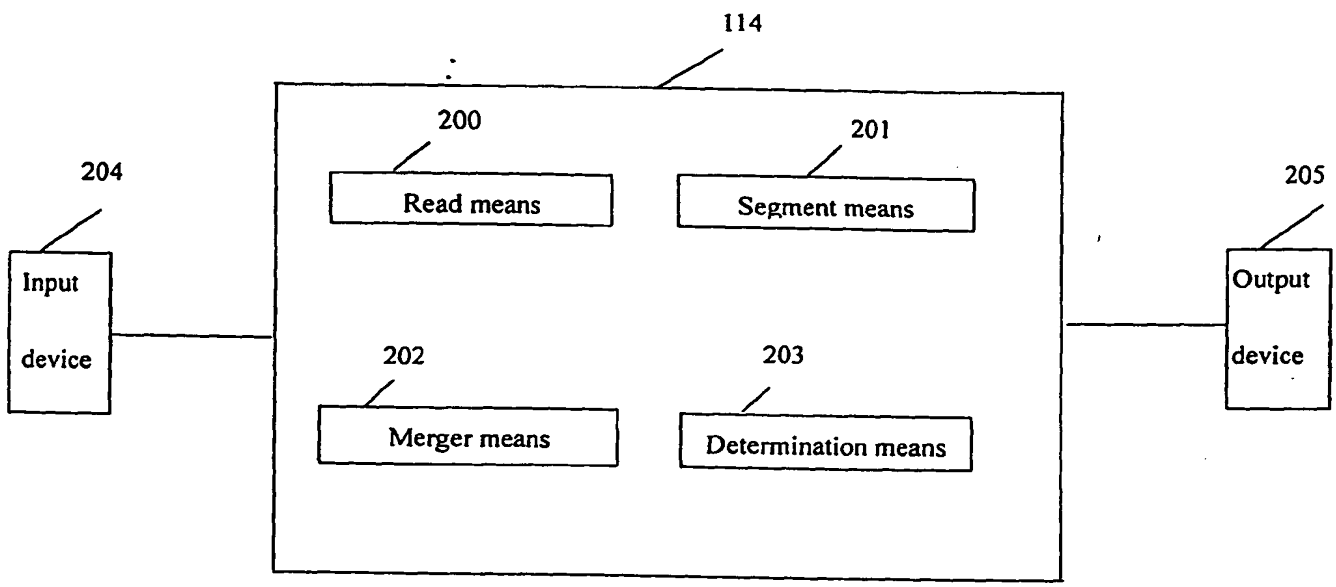

114
200
Read means
201
Segment means
204
Input
device
205
Output
device
202
Merger means
203
Determination means

Figure 2

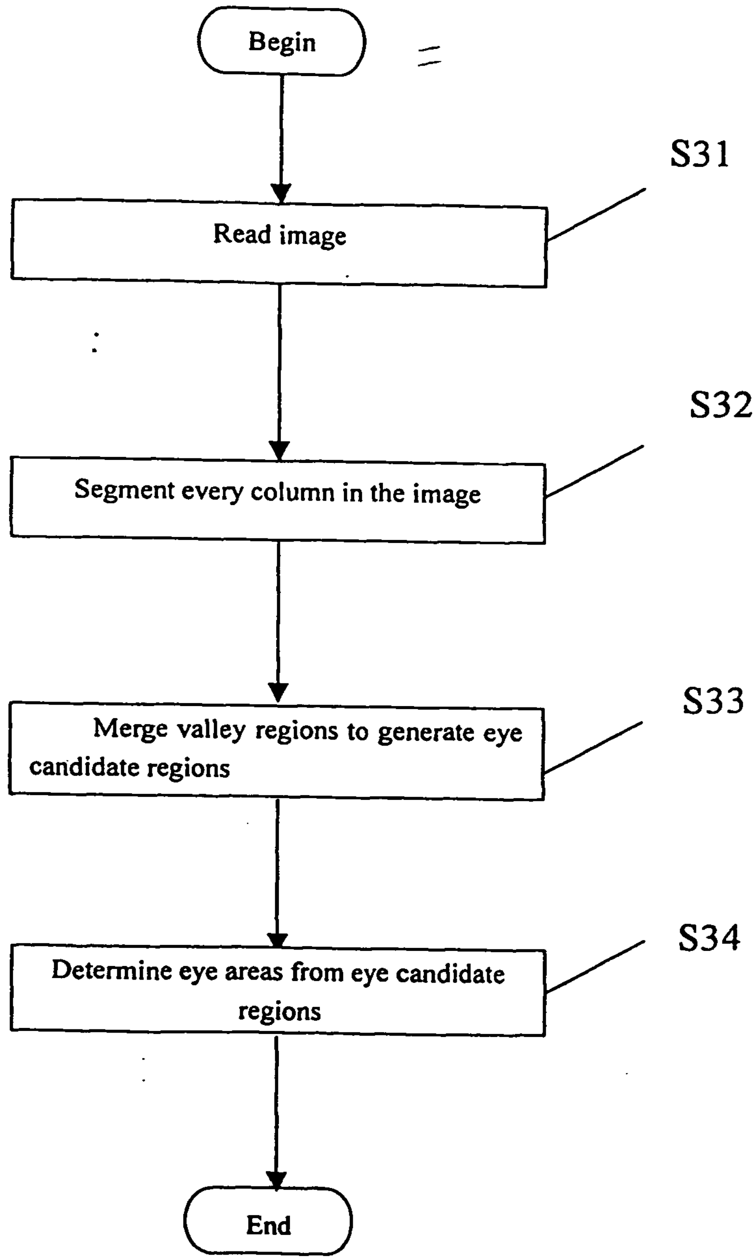

Begin
S31
Read image
S32
Segment every column in the image
S33
Merge valley regions to generate eye candidate regions
S34
Determine eye areas from eye candidate regions
End

Figure 3A

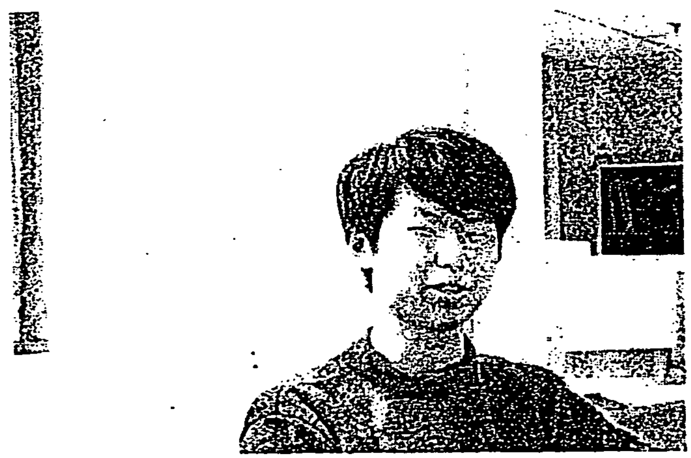


Figure 3B

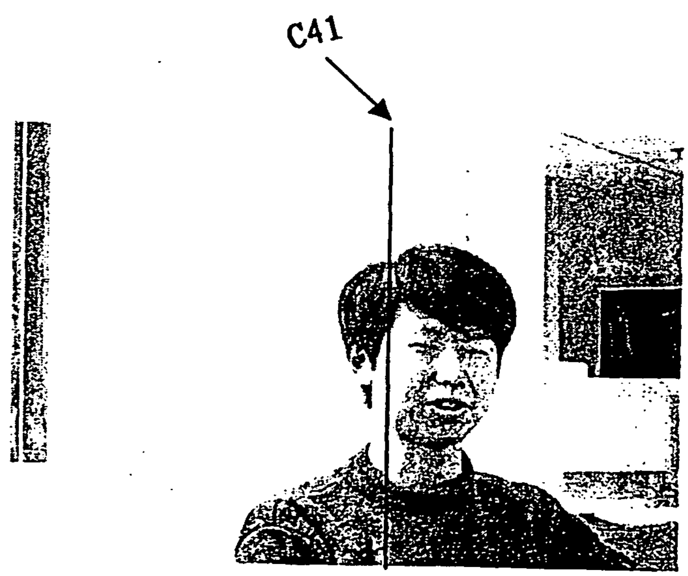


Figure 4B

Details of the Attorney Fee in item 5 of our debit note:

1. Fee for discussing patent application with Mr. Yamada in PeCan.
   April 10 Am 9:00 - 11:30
   April 14 Am 9:00 - 11:00
   charged hours: 2; Mr. Ma, Mr. zhang — USD 560.00

2. Fee for discussing patent application with Mr. Suzuki in PeCan.
   May 15: 9:00- 11:00
   charged hours: 2; Mr.Zhang — USD 260.00

3. Fee for discussing the China patent practice with Mr. Suzuki and Mr. Utsumi in our firm.
   May 17 Am 9:00 - 11:00
   charged hours: 1.5; Vice president Yang — USD 270.00

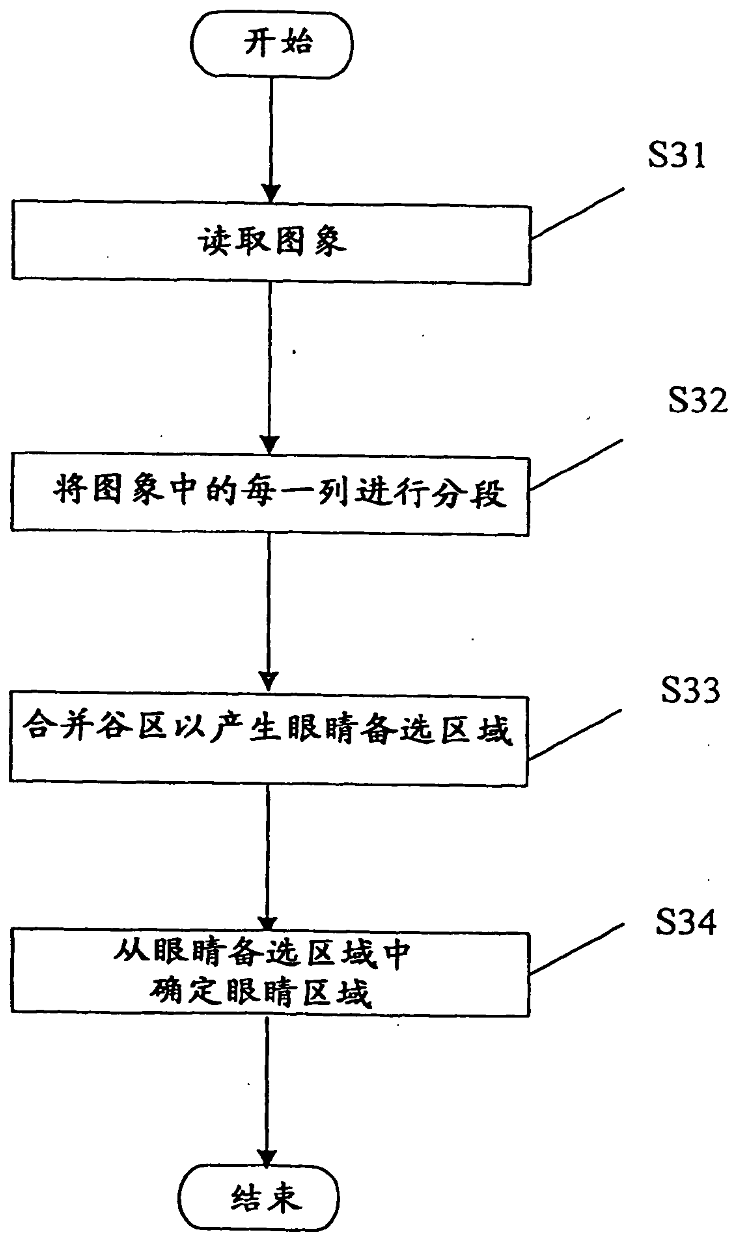
4. Fee of legal letter of May 24 commenting on first filing country.
   charged hours: 2; Vice president Yang — USD 360.00

5. Fee for discussing with the inventor on the invention.
   charged hours: 11; Mr. Zhang — USD 1430.00

6. Fee for drafting the specification, claims and preparing the drawings in English text and translating the English text into Chinese text.
   charged hours: 40: Mr. Zhang — USD 5200.00

Total amount of this item: USD 8080.00

摘 要 附 图


开始
S31
读取图象
S32
将图象中的每一列进行分段
S33
合并谷区以产生眼睛备选区域
S34
从眼睛备选区域中
确定眼睛区域
结束

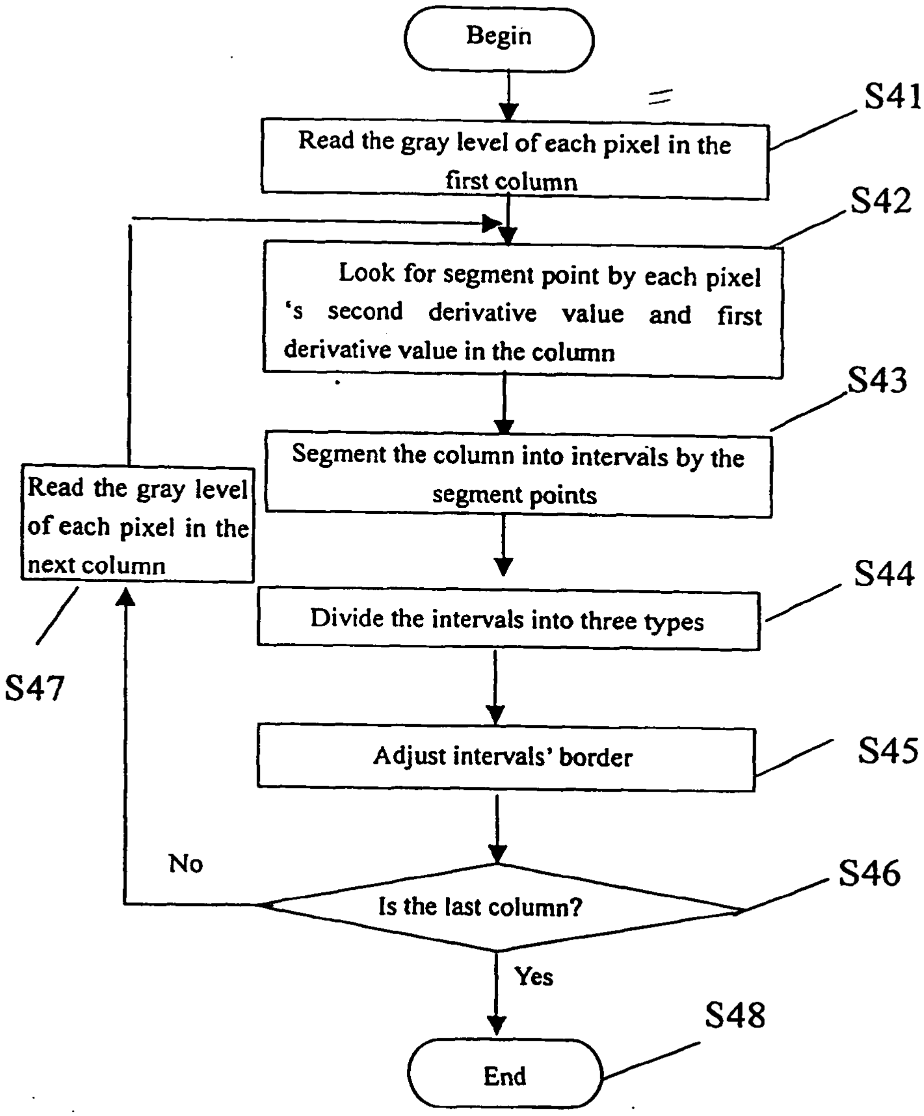

Begin
S41
Read the gray level of each pixel in the first column
S42
Look for segment point by each pixel 's second derivative value and first derivative value in the column
S43
Segment the column into intervals by the segment points
Read the gray level of each pixel in the next column
S44
Divide the intervals into three types
S47
Adjust intervals' border
S45
No
Is the last column?
S46
Yes
S48
End

Figure 4A

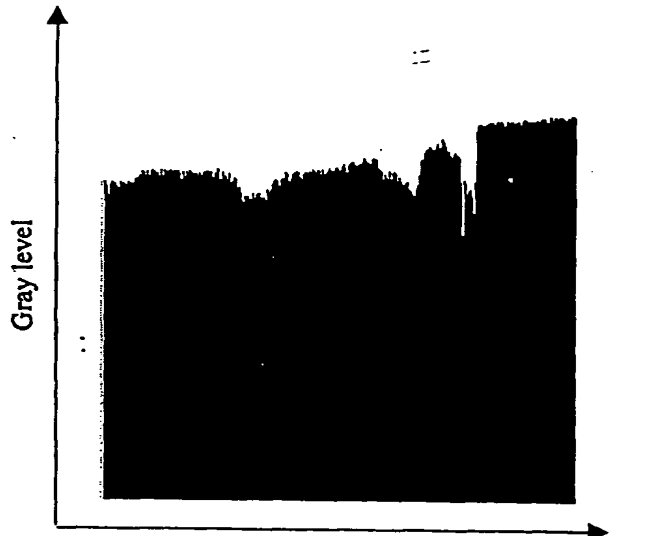


Figure 4C

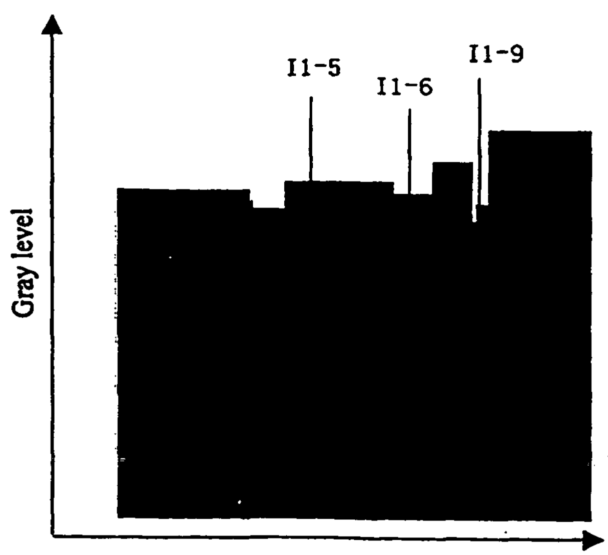


Figure 4D

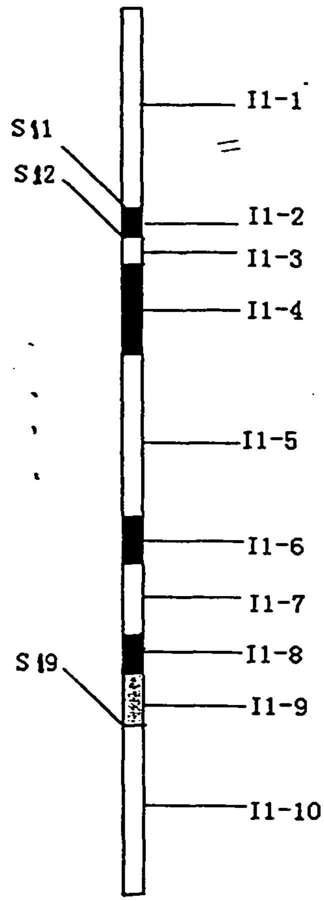


Figure 4E

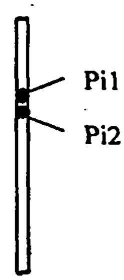


Figure 4F

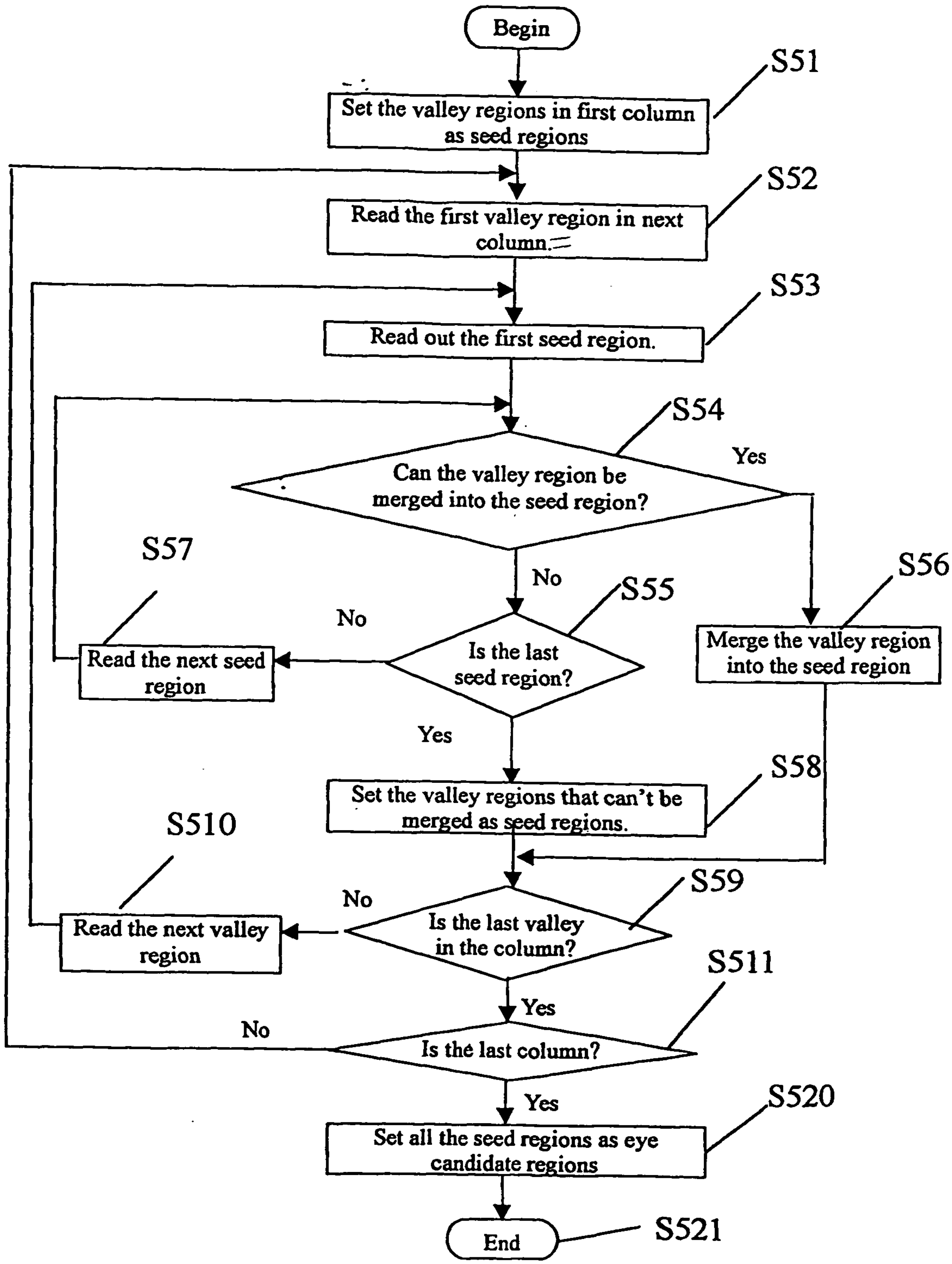

Begin
S51
Set the valley regions in first column as seed regions
S52
Read the first valley region in next column
S53
Read out the first seed region.
S54
Yes
Can the valley region be merged into the seed region?
S57
No
S55
S56
No
Read the next seed region
Is the last seed region?
Merge the valley region into the seed region
Yes
S58
Set the valley regions that can't be merged as seed regions.
S510
S59
No
Read the next valley region
Is the last valley in the column?
S511
Yes
No
Is the last column?
Yes
S520
Set all the seed regions as eye candidate regions
End
S521

Figure 5A

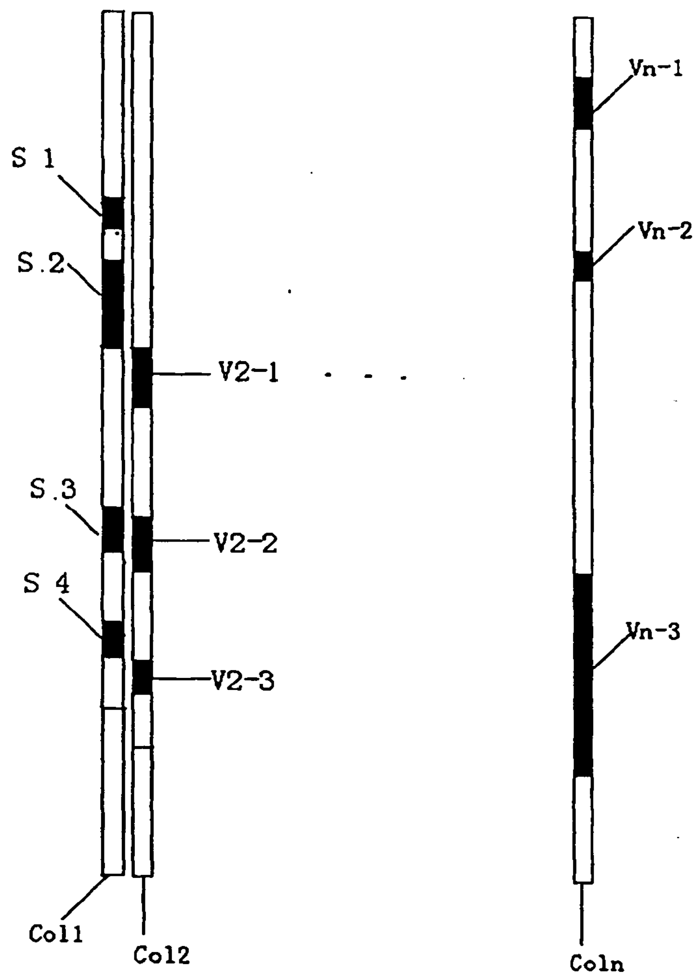


Figure. 5B

Figure 5C

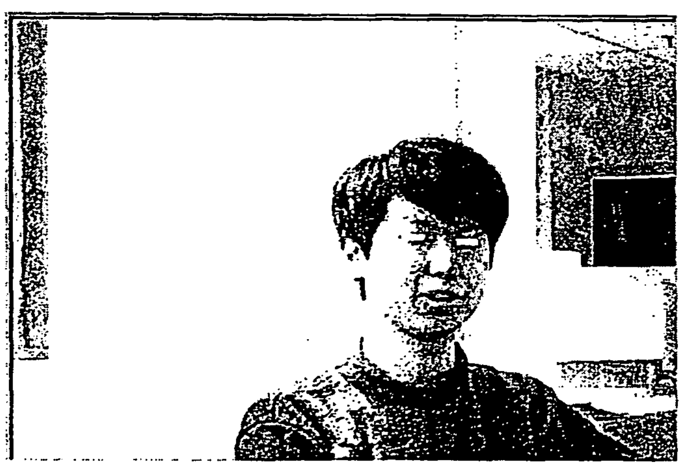


Figure 6C

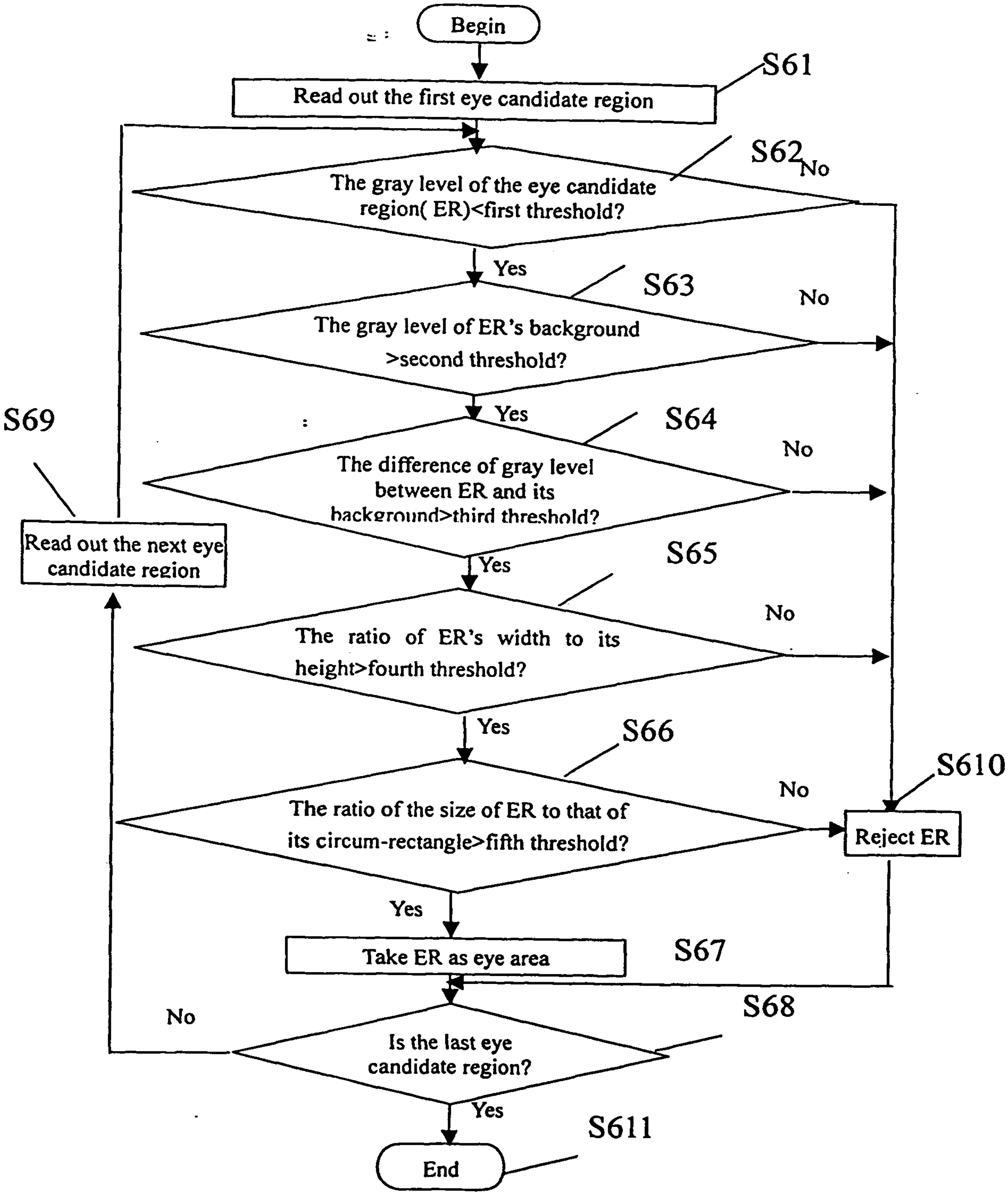

Begin
Read out the first eye candidate region
S61
The gray level of the eye candidate region(ER)<first threshold?
S62
No
Yes
S63
The gray level of ER's background >second threshold?
No
Yes
S64
The difference of gray level between ER and its background>third threshold?
No
S69
Read out the next eye candidate region
Yes
S65
The ratio of ER's width to its height>fourth threshold?
No
Yes
S66
The ratio of the size of ER to that of its circum-rectangle>fifth threshold?
No
S610
Reject ER
Yes
Take ER as eye area
S67
S68
No
Is the last eye candidate region?
Yes
S611
End

Figure 6A

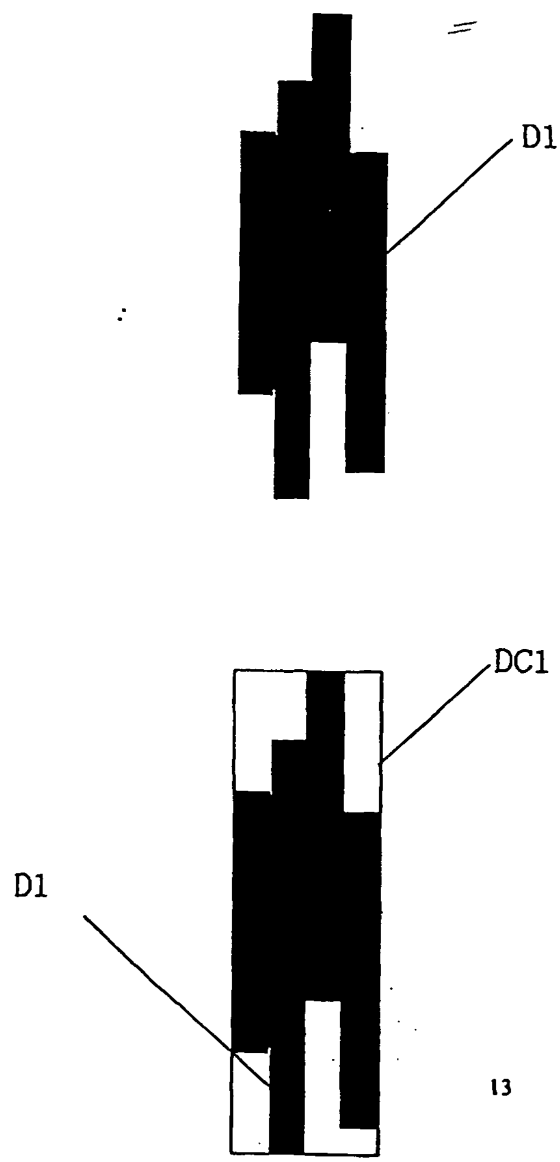
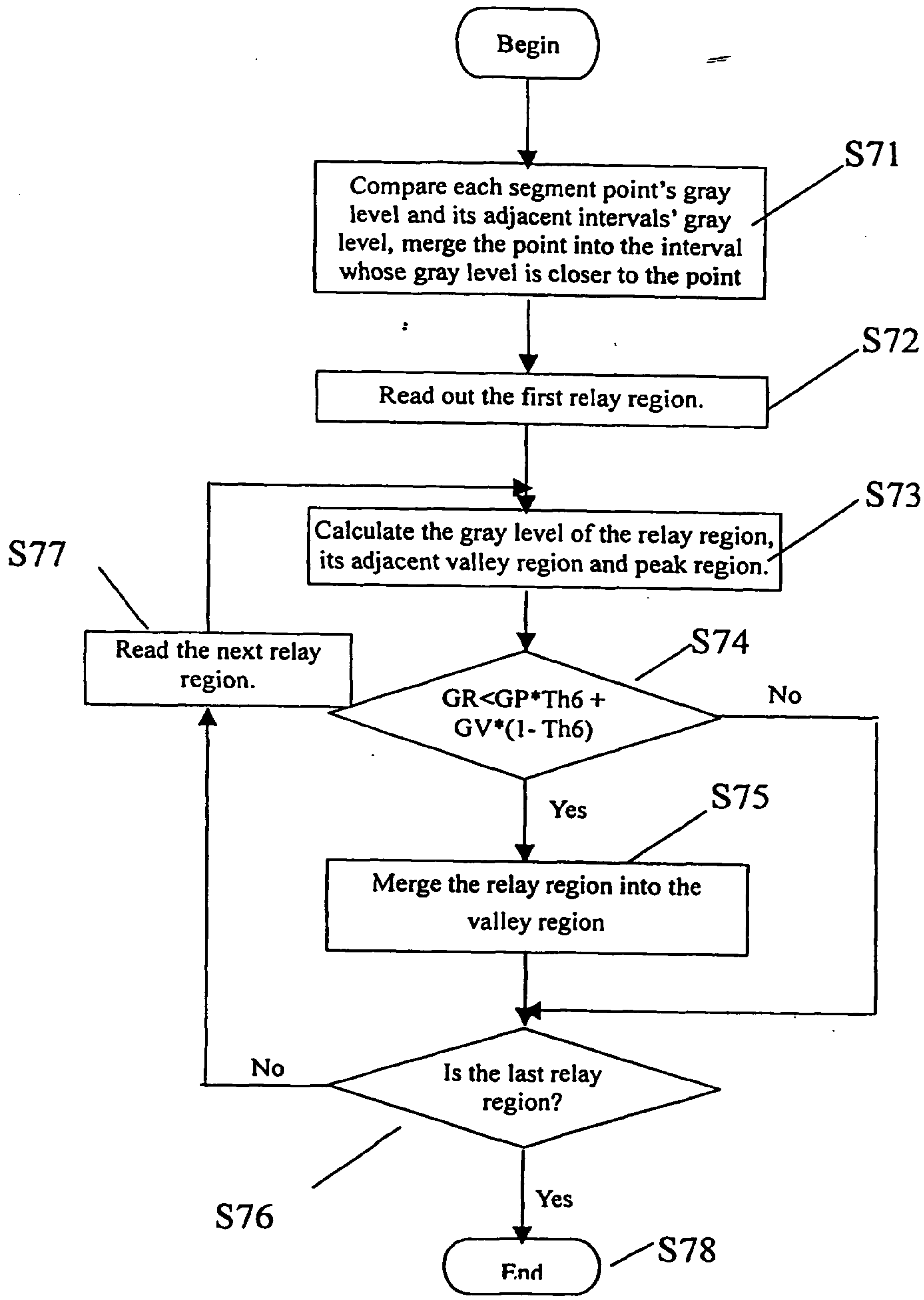


Figure 6B



Begin
S71
Compare each segment point's gray level and its adjacent intervals' gray level, merge the point into the interval whose gray level is closer to the point
S72
Read out the first relay region.
S73
Calculate the gray level of the relay region, its adjacent valley region and peak region.
S77
Read the next relay region.
S74
GR<GP*Th6 + GV*(1- Th6)
No
Yes
S75
Merge the relay region into the valley region
No
Is the last relay region?
S76
Yes
End
S78

Figure 7A

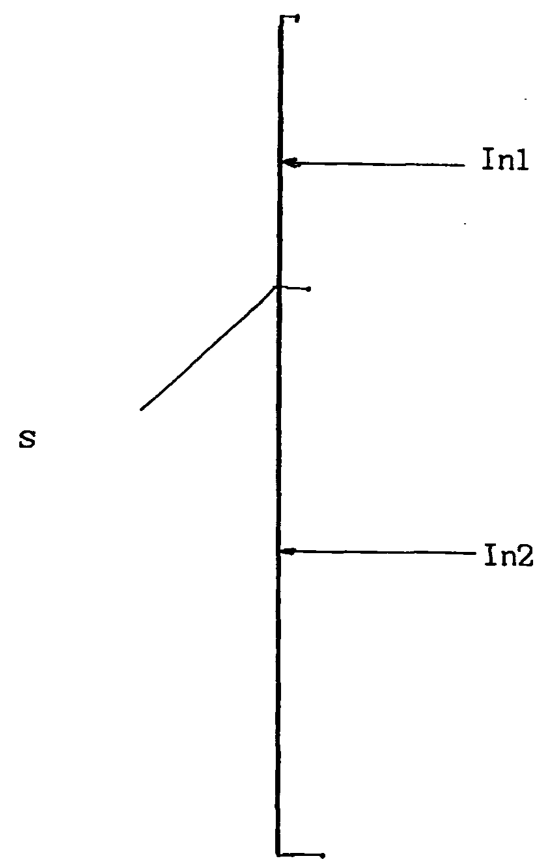


Figure 7B

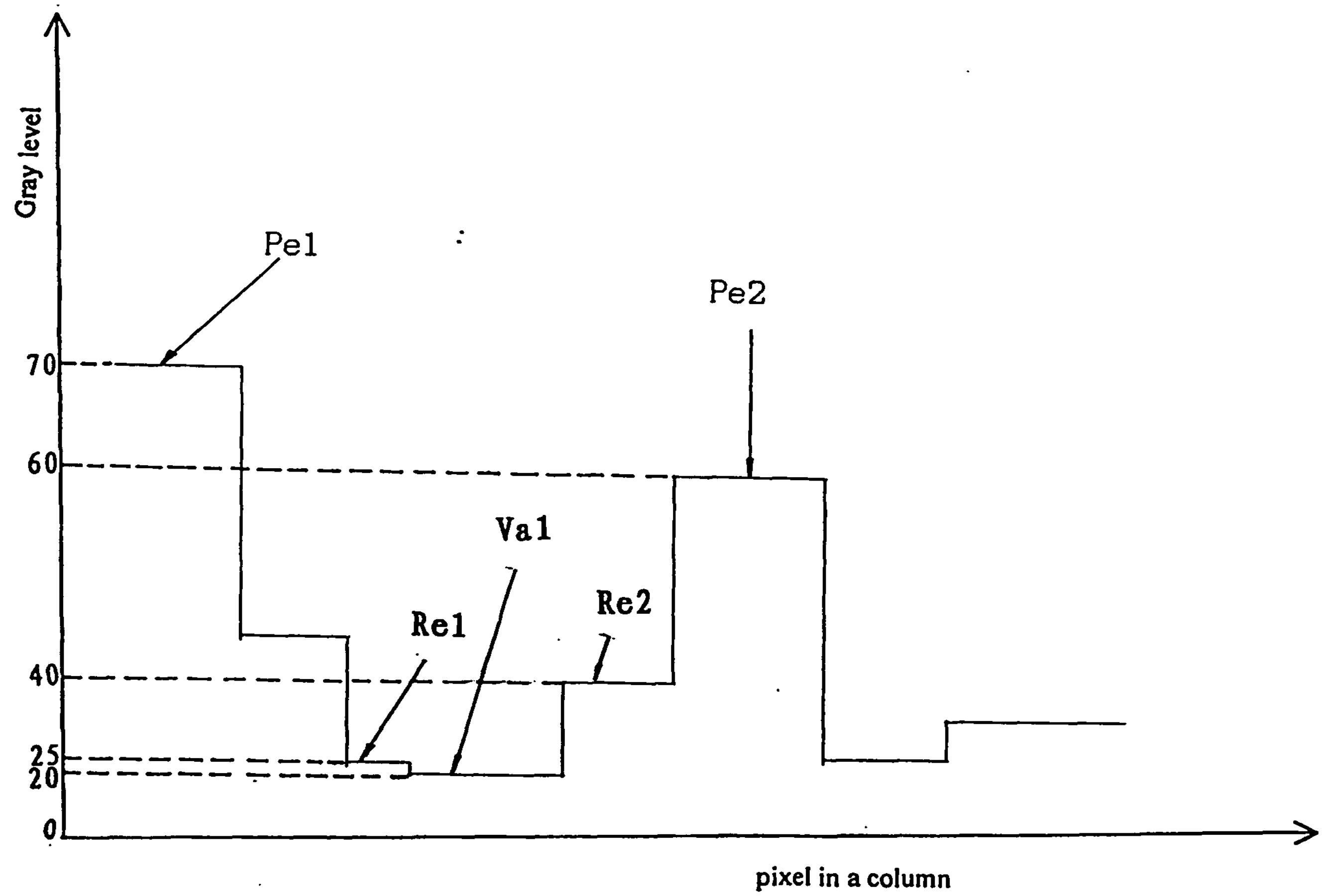


Figure 7C

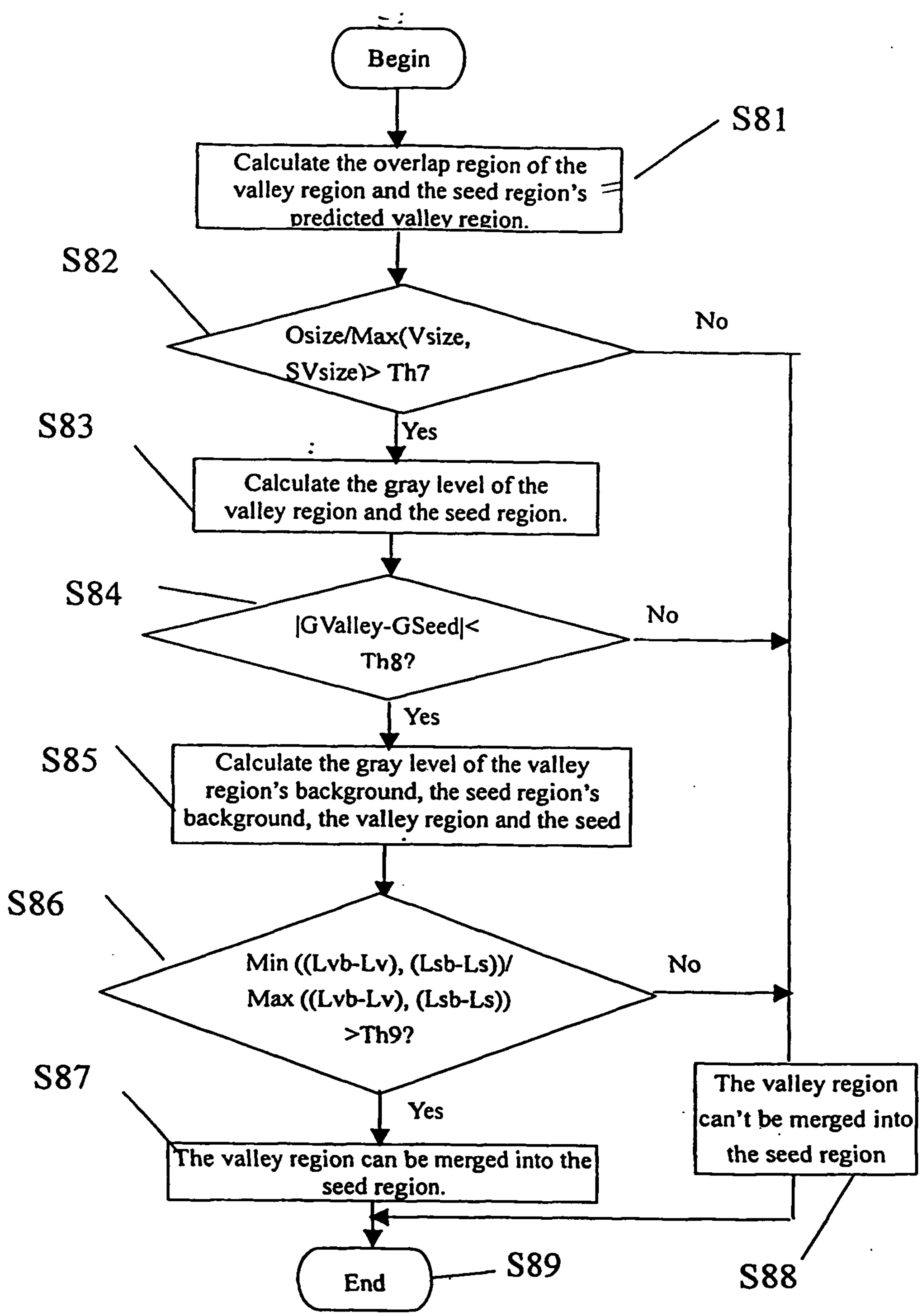

Begin
S81
Calculate the overlap region of the valley region and the seed region's predicted valley region.
S82
Osize/Max(Vsize, SVsize)> Th7
No
Yes
S83
Calculate the gray level of the valley region and the seed region.
S84
|GValley-GSeed|< Th8?
No
Yes
S85
Calculate the gray level of the valley region's background, the seed region's background, the valley region and the seed
S86
Min ((Lvb-Lv), (Lsb-Ls))/ Max ((Lvb-Lv), (Lsb-Ls)) >Th9?
No
Yes
S87
The valley region can be merged into the seed region.
The valley region can't be merged into the seed region
End
S89
S88

Figure 8A

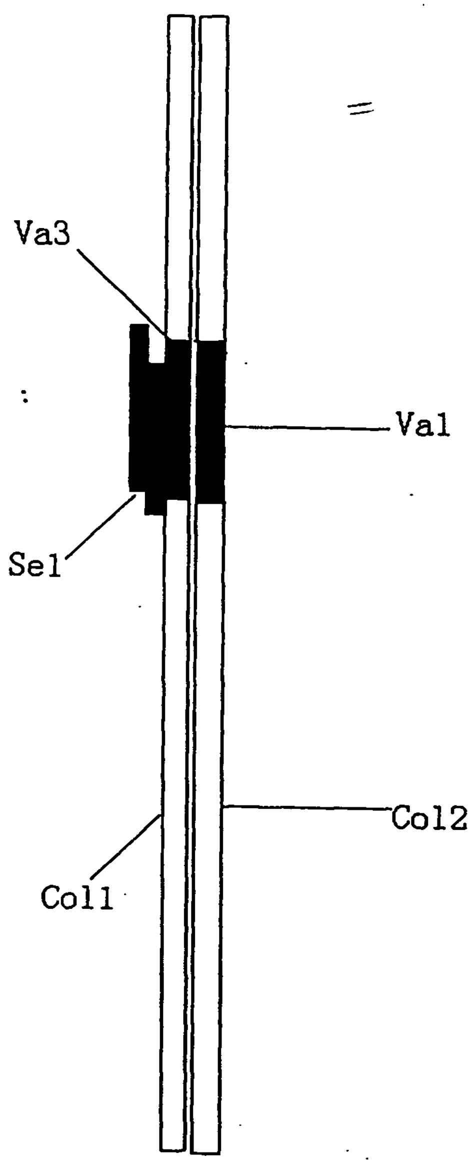


Figure 8B

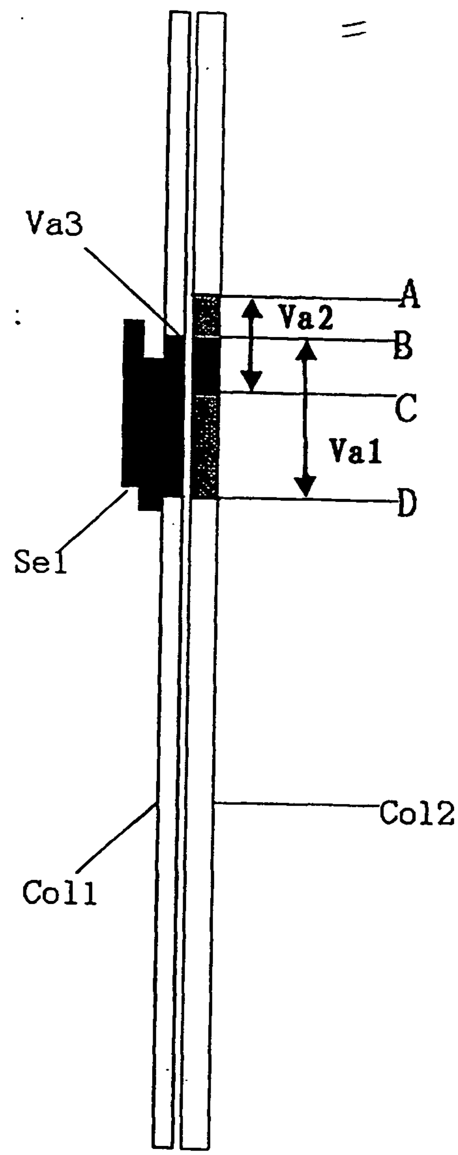
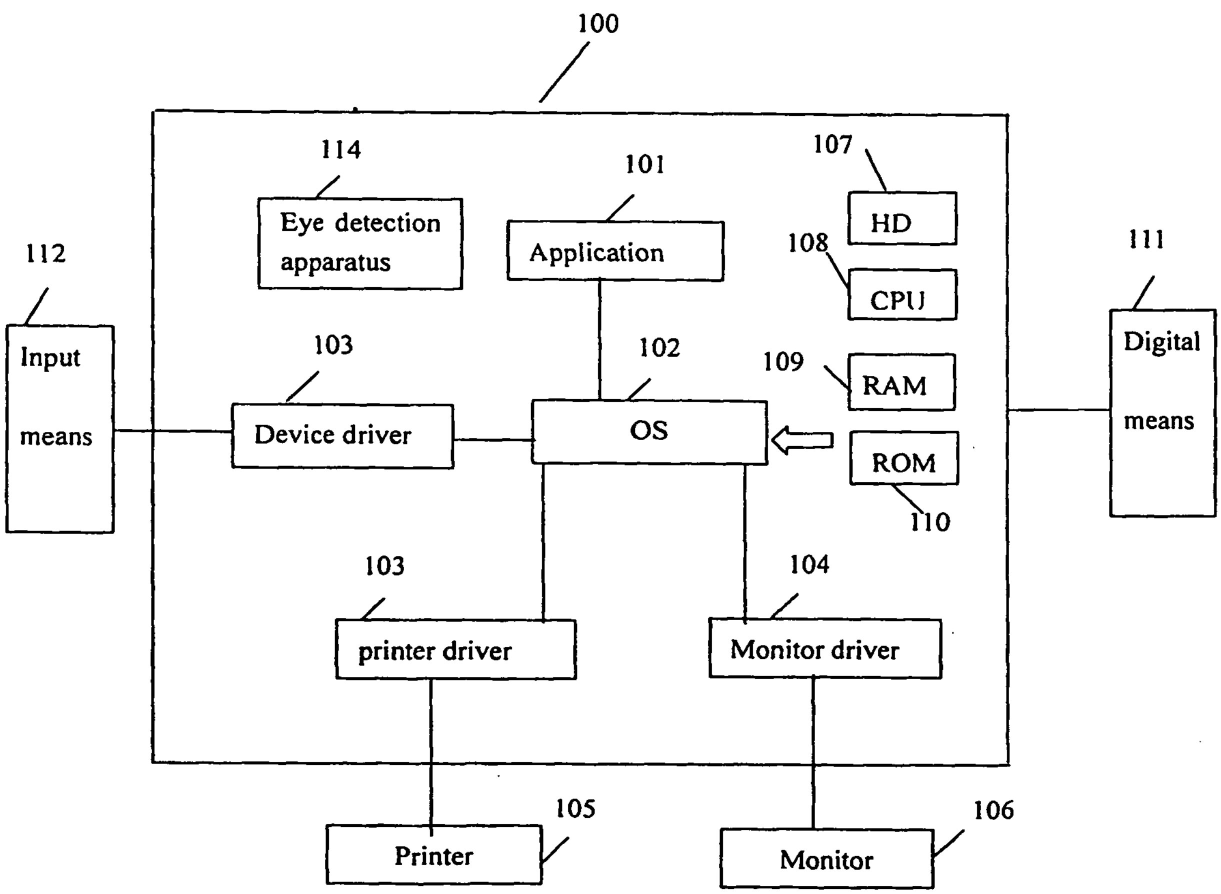


Figure 8C



100
114
Eye detection apparatus
101
Application
107
HD
108
CPU
112
Input means
103
Device driver
102
OS
109
RAM
ROM
110
111
Digital means
103
printer driver
104
Monitor driver
105
Printer
106
Monitor

Figure 1

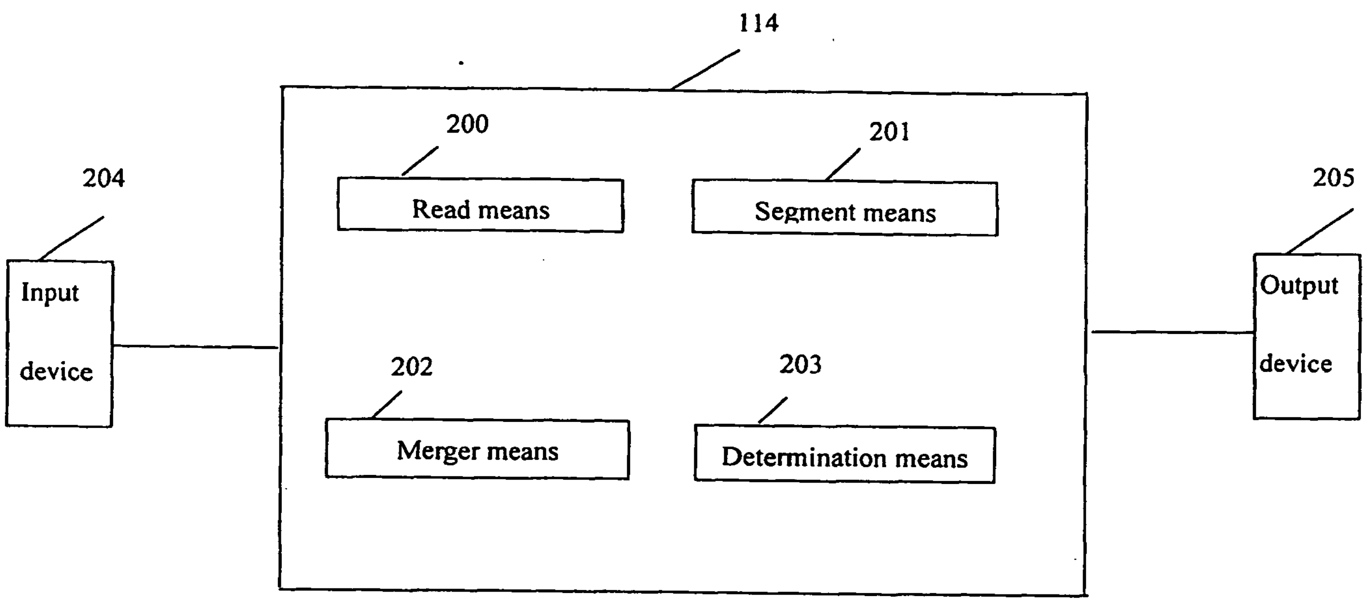

114
200
Read means
201
Segment means
204
Input
device
205
Output
device
202
Merger means
203
Determination means

Figure 2

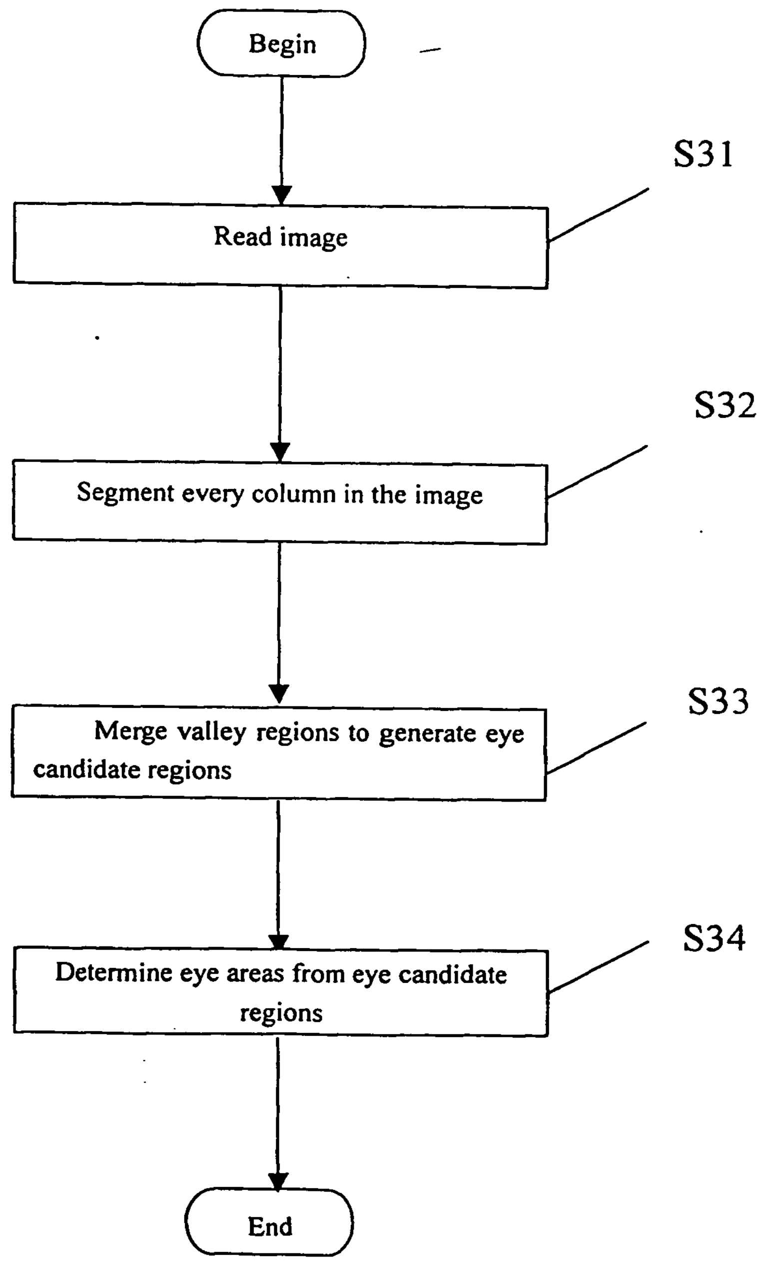

Begin
S31
Read image
S32
Segment every column in the image
S33
Merge valley regions to generate eye candidate regions
S34
Determine eye areas from eye candidate regions
End

Figure 3A

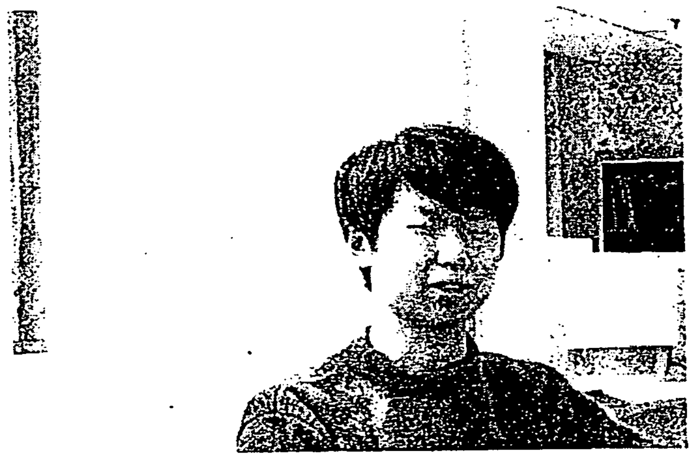


Figure 3B

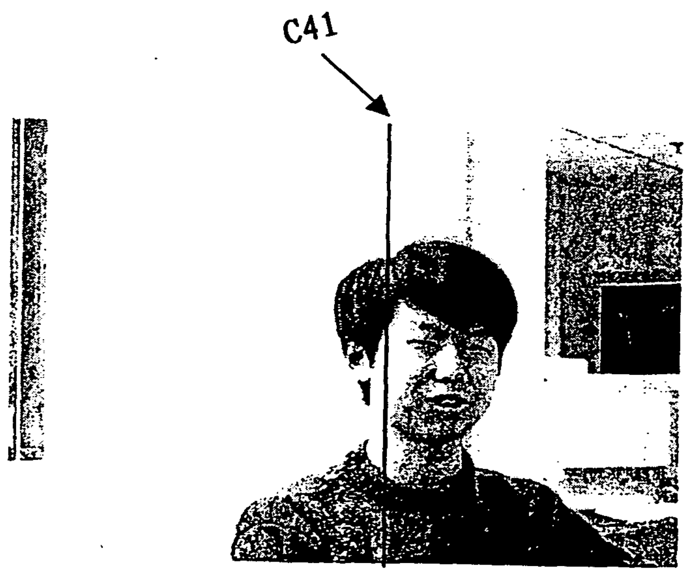


Figure 4B

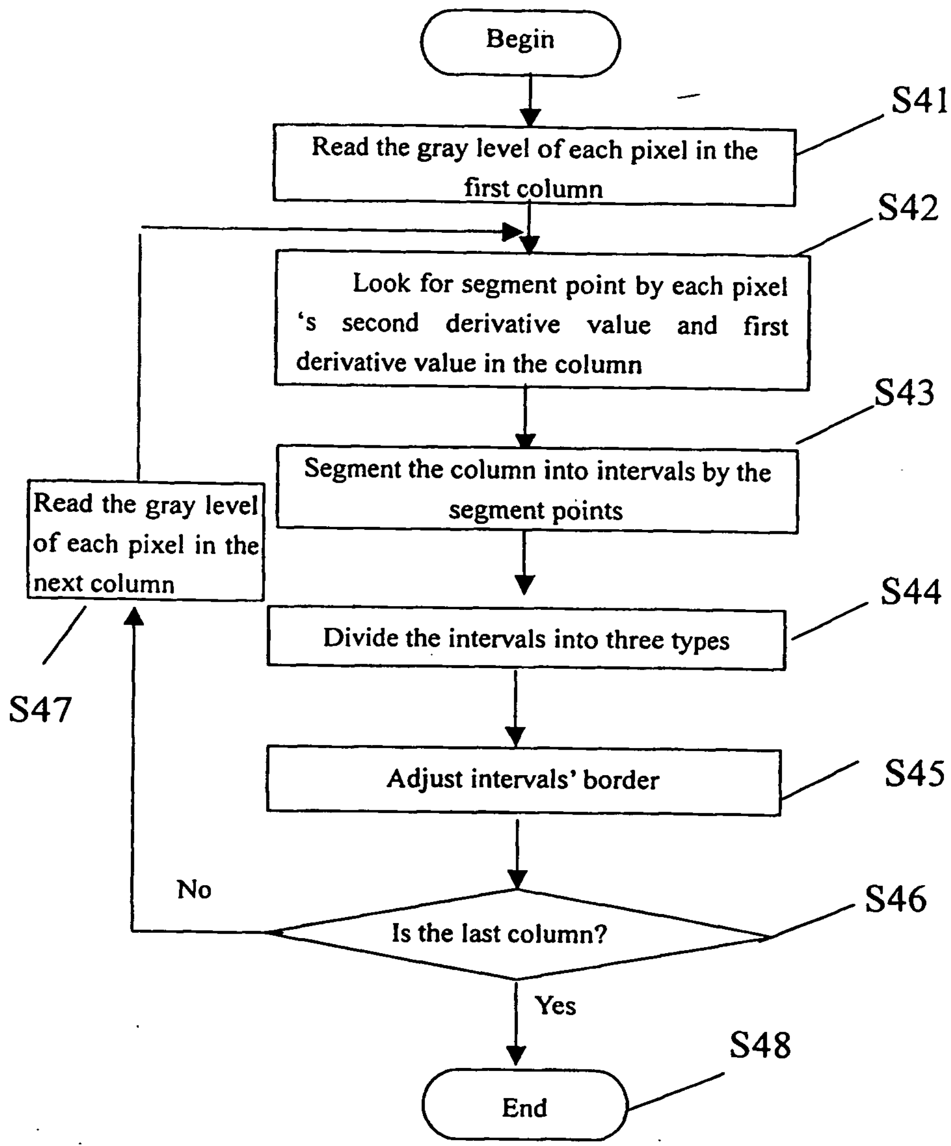

Begin
S41
Read the gray level of each pixel in the first column
S42
Look for segment point by each pixel 's second derivative value and first derivative value in the column
S43
Segment the column into intervals by the segment points
Read the gray level of each pixel in the next column
S44
Divide the intervals into three types
S47
Adjust intervals' border
S45
No
Is the last column?
S46
Yes
S48
End

Figure 4A

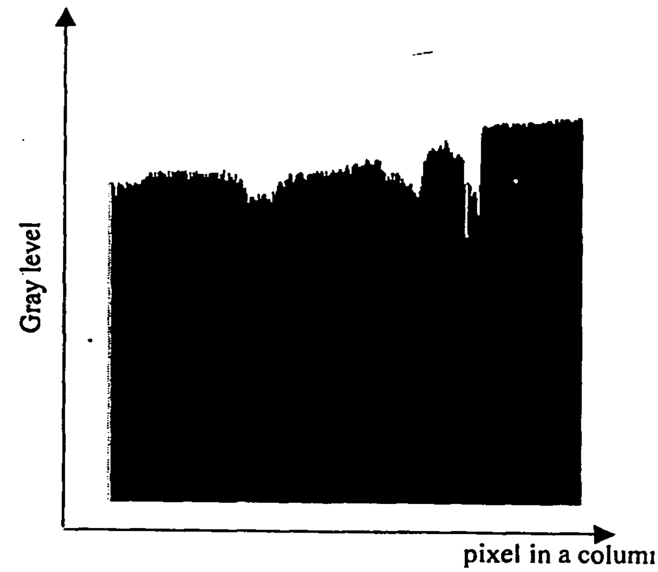
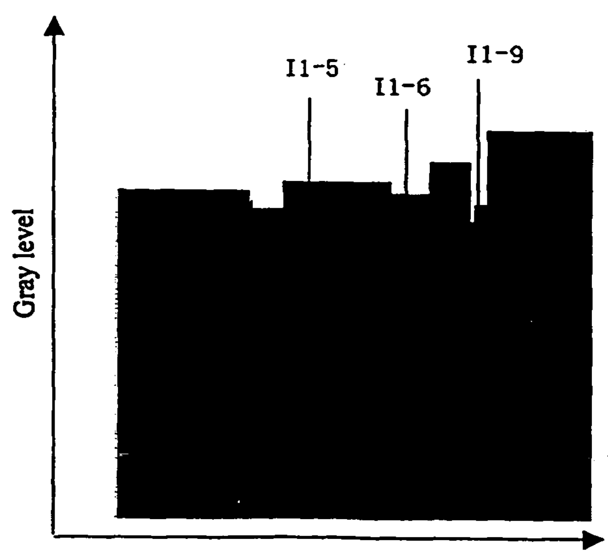


Figure 4C



pixel in a column

Figure 4D

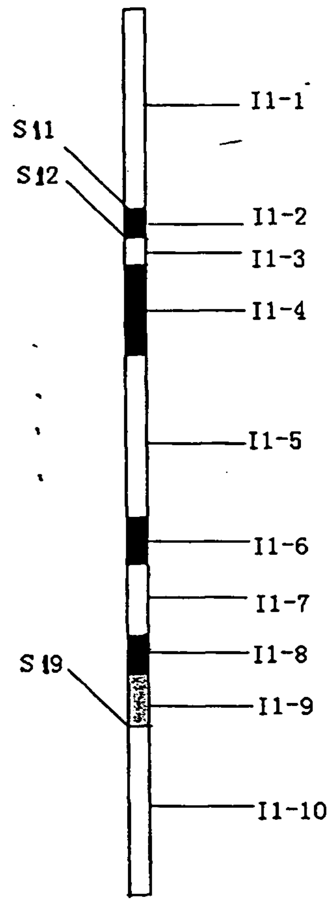


Figure 4E

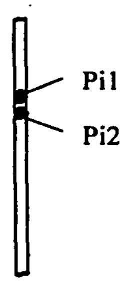


Figure 4F

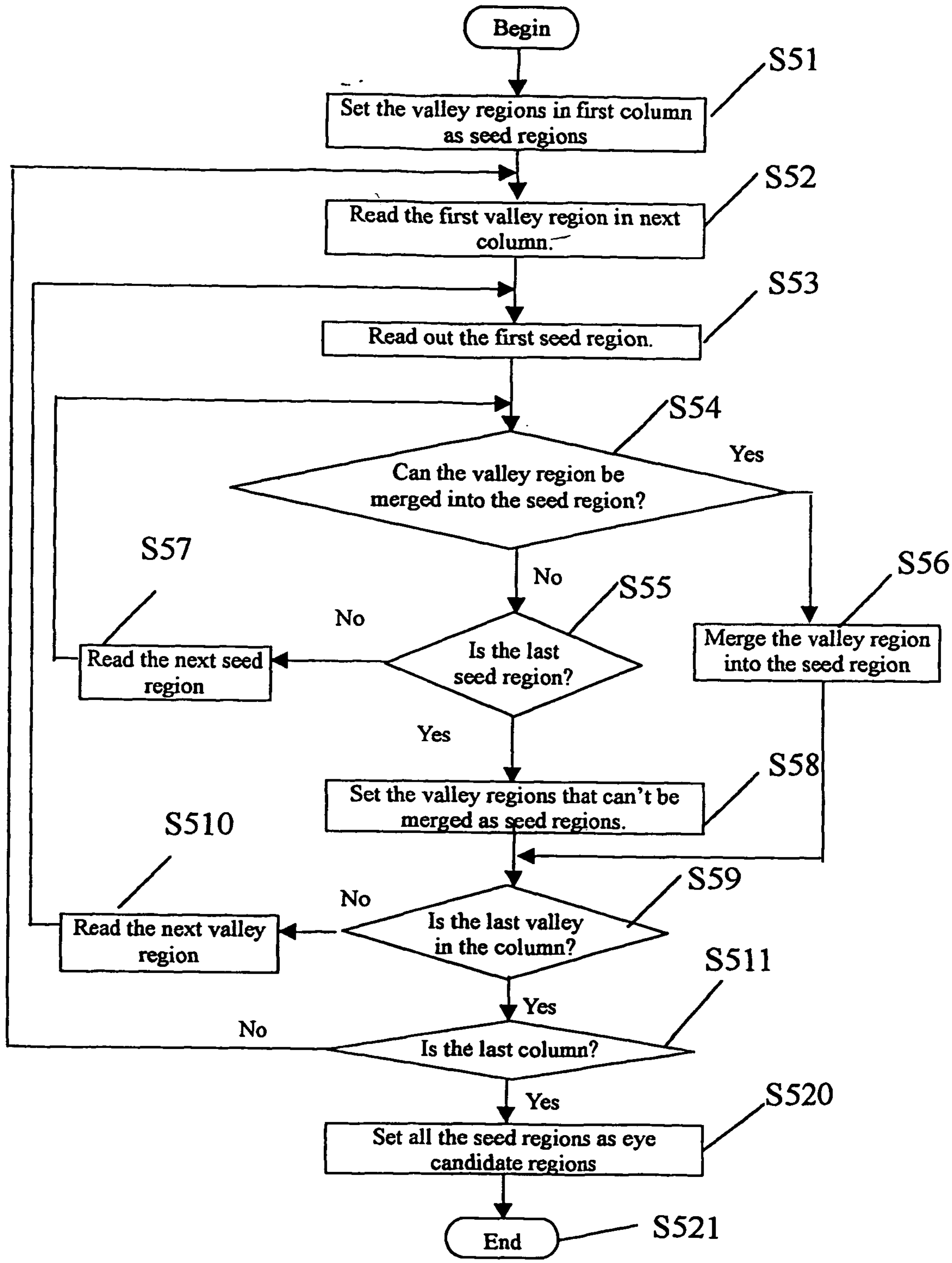

Begin
S51
Set the valley regions in first column as seed regions
S52
Read the first valley region in next column.
S53
Read out the first seed region.
S54
Can the valley region be merged into the seed region?
Yes
No
S55
Is the last seed region?
No
S57
Read the next seed region
S56
Merge the valley region into the seed region
Yes
S58
Set the valley regions that can't be merged as seed regions.
S59
Is the last valley in the column?
No
S510
Read the next valley region
Yes
S511
Is the last column?
No
Yes
S520
Set all the seed regions as eye candidate regions
End
S521

Figure 5A

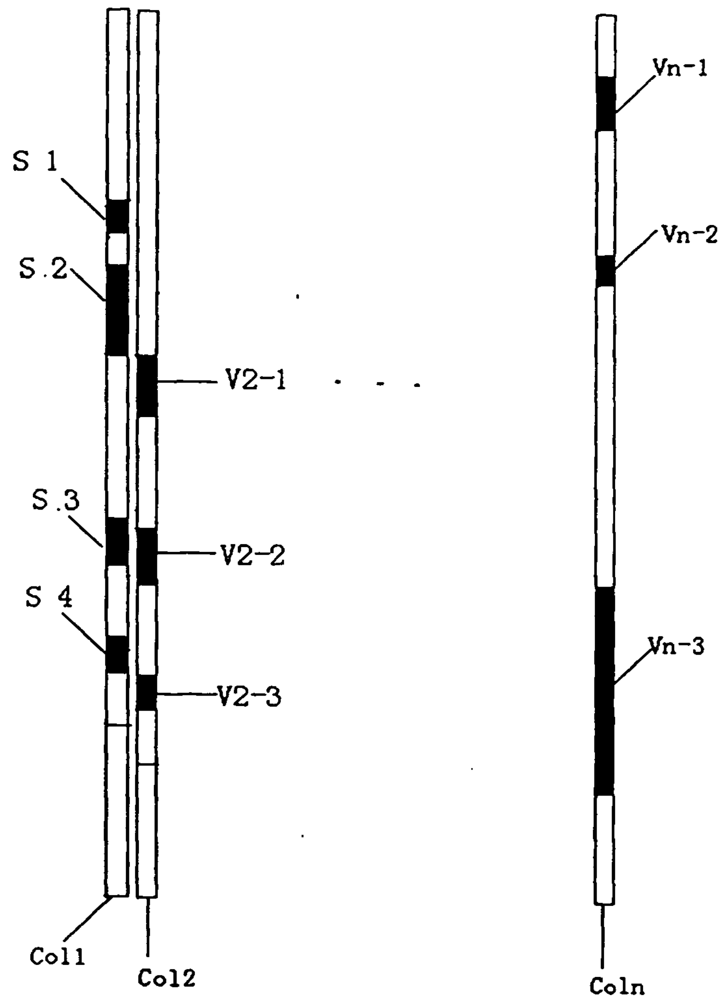


Figure. 5B

Figure 5C

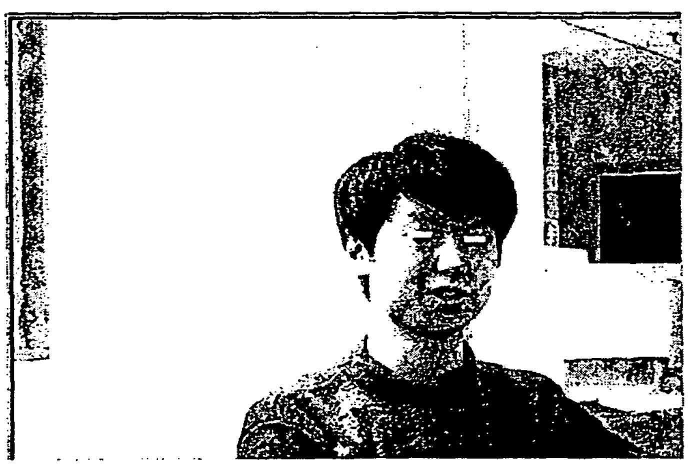


Figure 6C

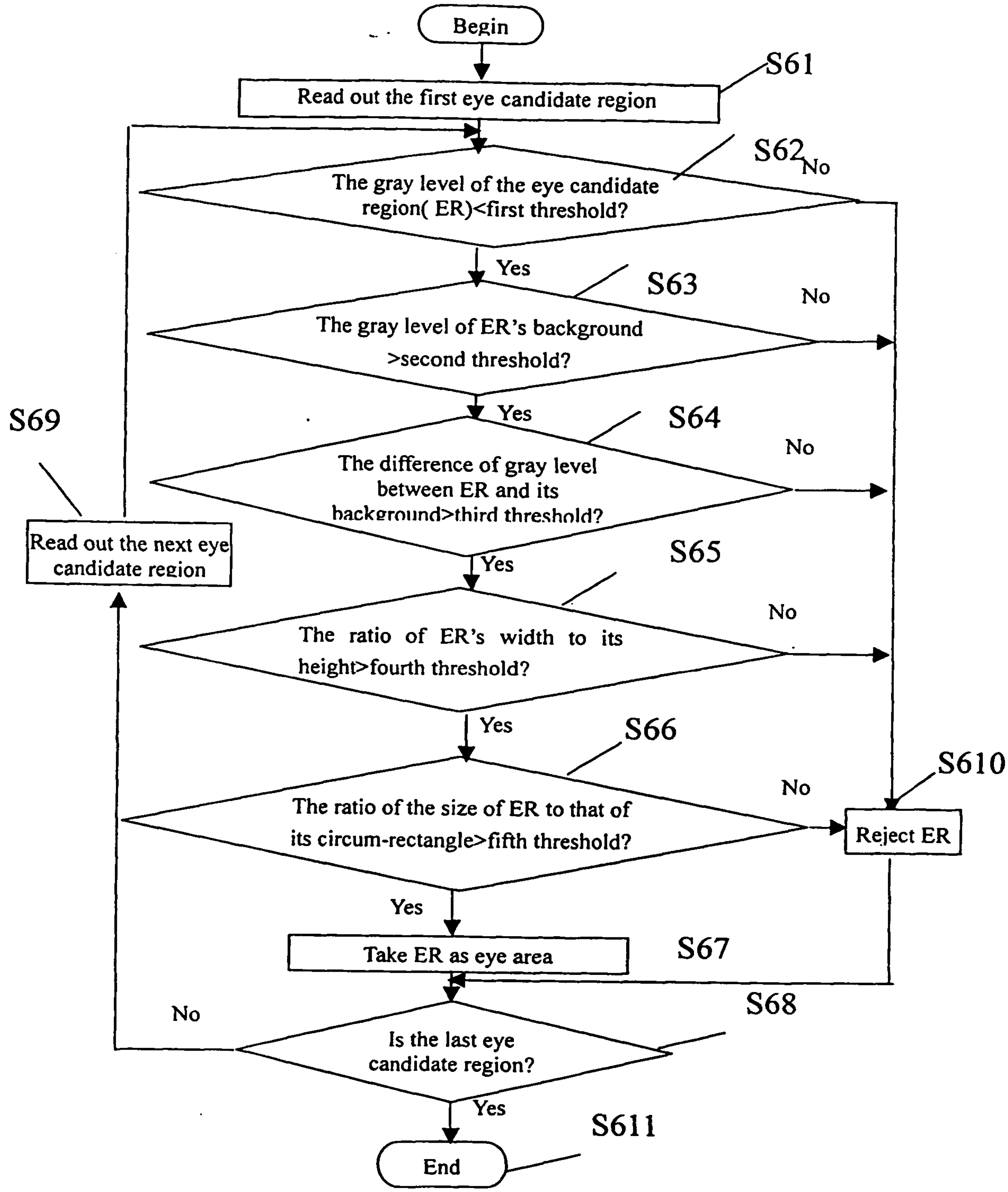

Begin
S61
Read out the first eye candidate region
S62
No
The gray level of the eye candidate region(ER)<first threshold?
Yes
S63
No
The gray level of ER's background >second threshold?
Yes
S64
No
The difference of gray level between ER and its background>third threshold?
S69
Read out the next eye candidate region
Yes
S65
No
The ratio of ER's width to its height>fourth threshold?
Yes
S66
S610
No
The ratio of the size of ER to that of its circum-rectangle>fifth threshold?
Reject ER
Yes
Take ER as eye area
S67
S68
No
Is the last eye candidate region?
Yes
S611
End

Figure 6A

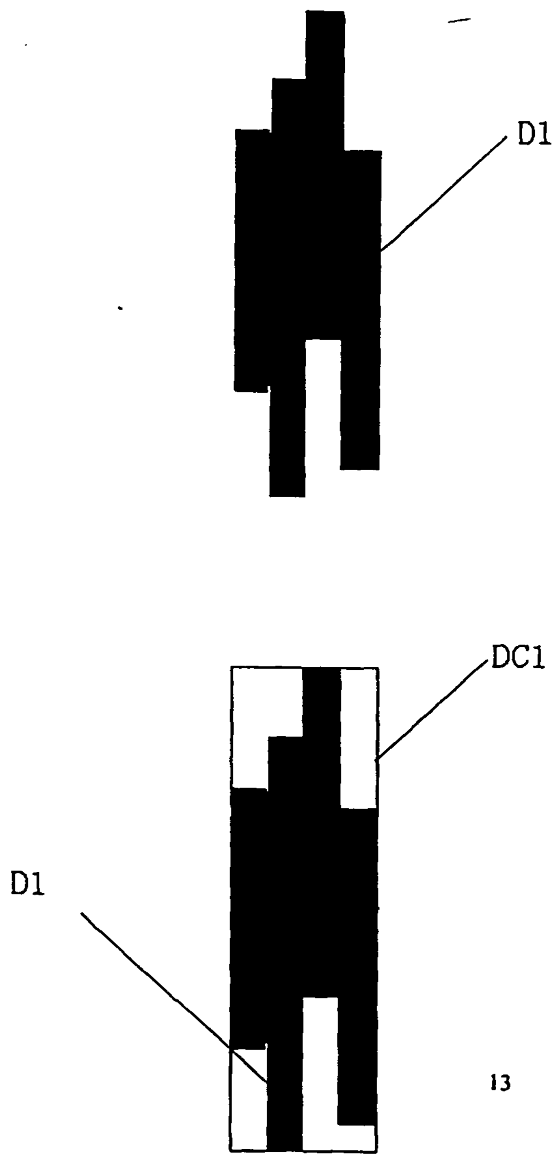


Figure 6B

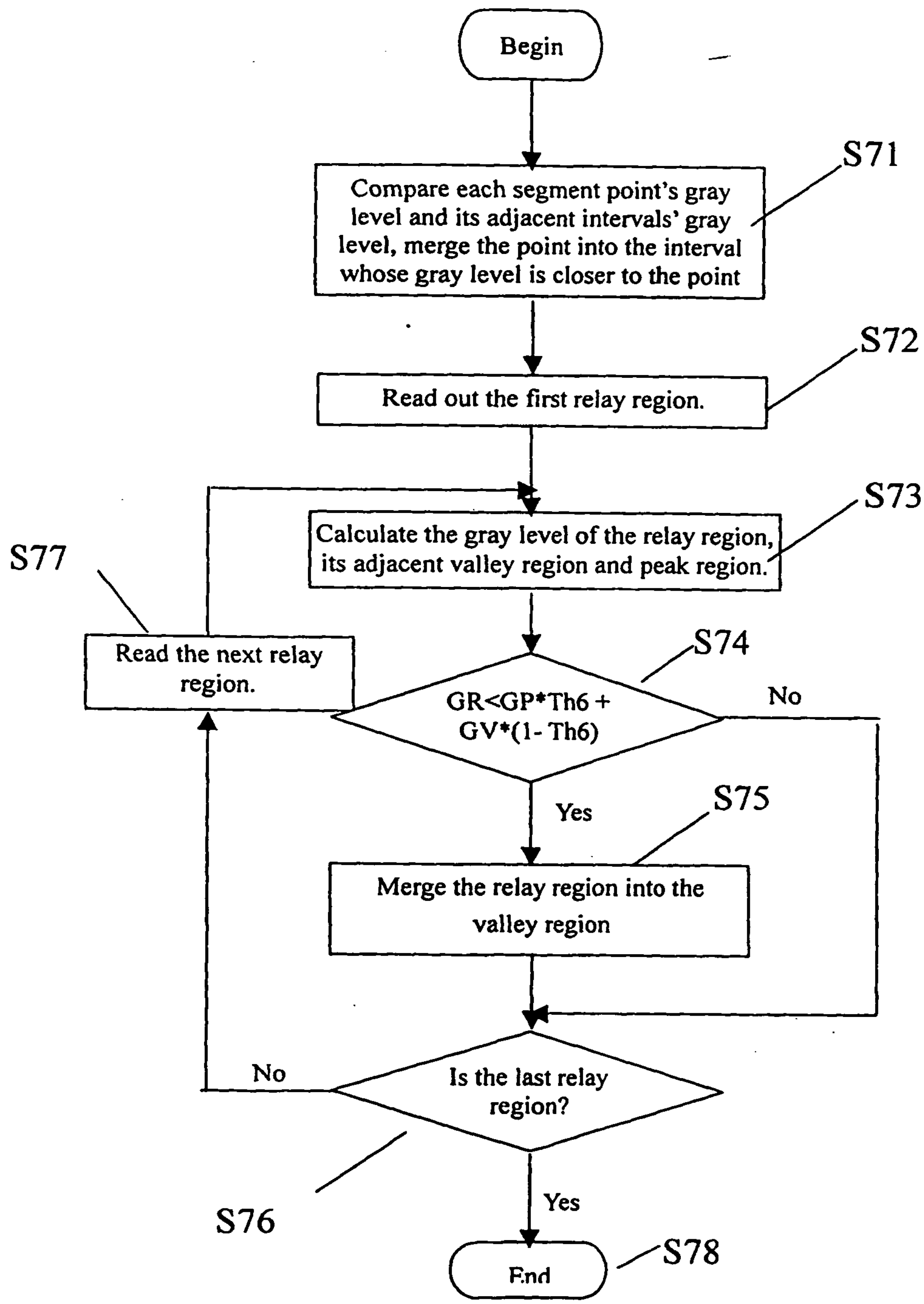

Begin
S71
Compare each segment point's gray level and its adjacent intervals' gray level, merge the point into the interval whose gray level is closer to the point
S72
Read out the first relay region.
S73
Calculate the gray level of the relay region, its adjacent valley region and peak region.
S77
Read the next relay region.
S74
GR<GP*Th6 + GV*(1- Th6)
No
Yes
S75
Merge the relay region into the valley region
No
Is the last relay region?
Yes
S76
End
S78

Figure 7A

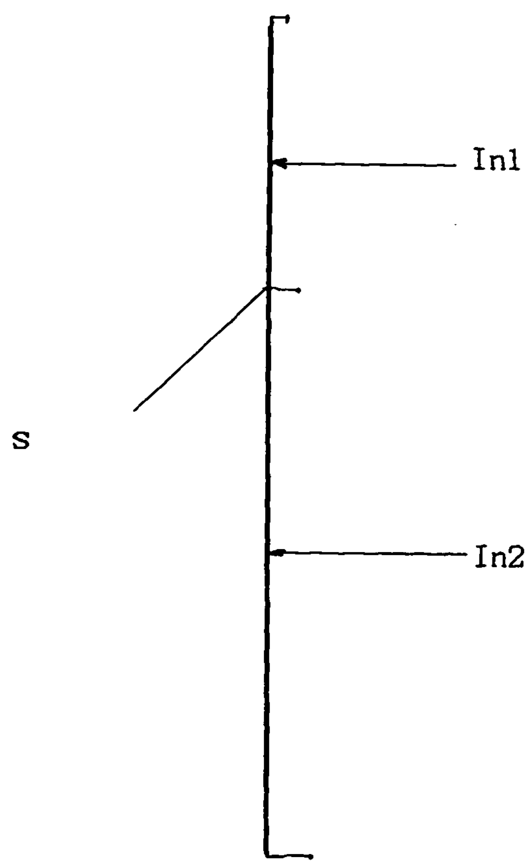


Figure 7B

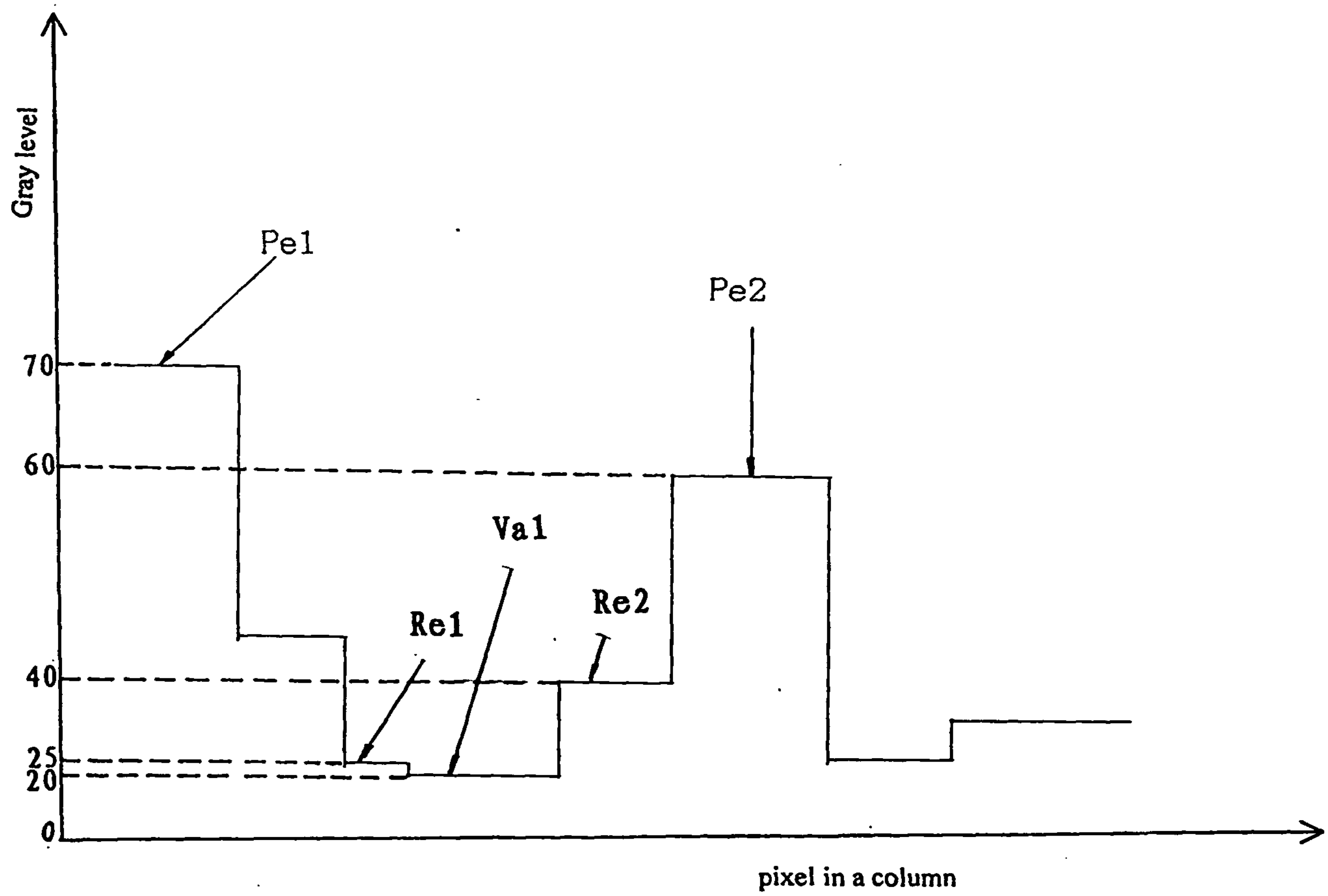


Figure 7C

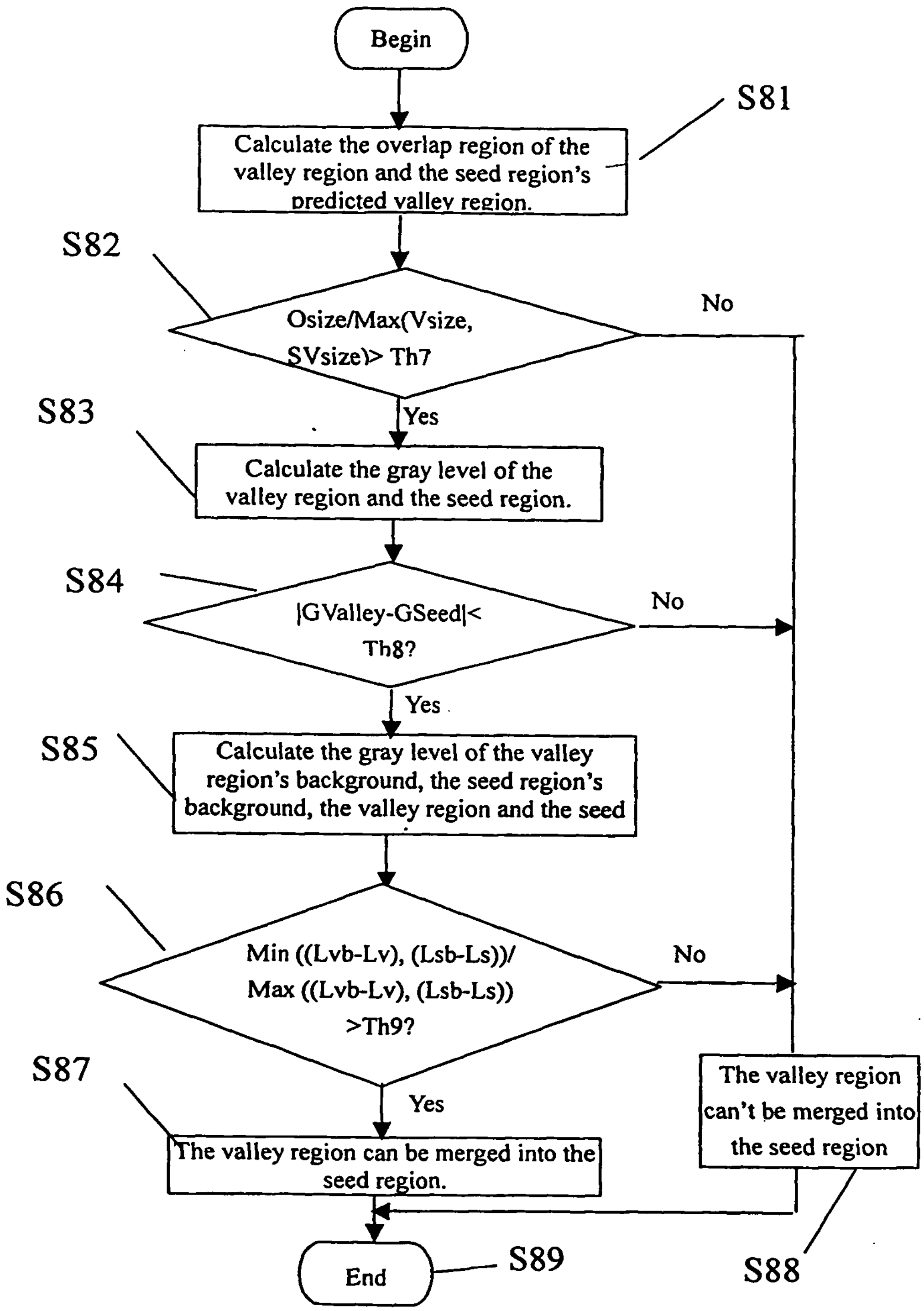

Begin
S81
Calculate the overlap region of the valley region and the seed region's predicted valley region.
S82
Osize/Max(Vsize, SVsize)> Th7
No
Yes
S83
Calculate the gray level of the valley region and the seed region.
S84
|GValley-GSeed|< Th8?
No
Yes
S85
Calculate the gray level of the valley region's background, the seed region's background, the valley region and the seed
S86
Min ((Lvb-Lv), (Lsb-Ls))/ Max ((Lvb-Lv), (Lsb-Ls)) >Th9?
No
Yes
S87
The valley region can be merged into the seed region.
The valley region can't be merged into the seed region
End
S89
S88

Figure 8A

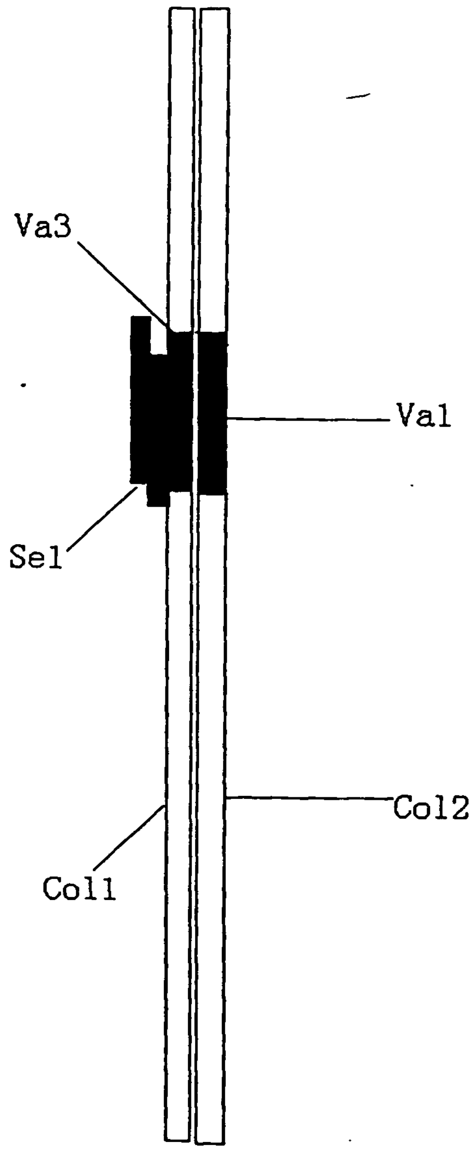


Figure 8B

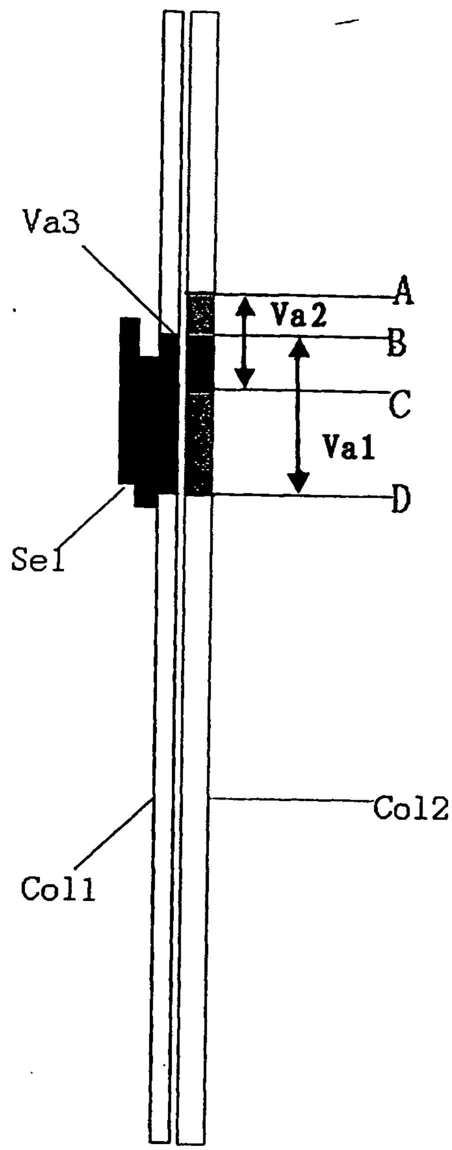


Figure 8C